SPACE SHUTTLE

Solid Rocket Motors
Thiokol Corporation

TWR-17543, Vol. VII
ECS 1012

FLIGHT SET 360T004 (STS-30) FIELD JOINT PROTECTION SYSTEM FINAL REPORT

20 September 1989

Prepared for:

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
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MARSHALL SPACE FLIGHT CENTER, ALABAMA 35812

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Thiokol CORPORATION
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Flight Set 360T004 (STS-30)
Field Joint Protection System Final Report
Volume 7
Final Report

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ACRONYMS

JPS	Joint Protection System
RSRM	Redesigned Solid Rocket Motor
RTD	Resistance Temperature Device
TPS	Thermal Protection System
PEEP	Post-Flight Engineering and Evaluation Plan
PRs	Problem Reports
DWV	Dielectric Withstanding Voltage
MAB	Malfunction Analysis Branch

ABSTRACT

This report contains the prelaunch functioning data of the Joint Protection Systems (JPS) used on STS-30. Also included is the post-flight condition of the JPS components following the launch and recovery of the two RSRM boosters. The JPS components are:

1. Field Joint Heaters
2. Field Joint Sensors
3. Field Joint Moisture Seal
4. Moisture Seal Kevlar Retaining Straps
5. Field Joint External Insulation
6. Vent Valve
7. Power Cables
8. Igniter Heater

1.0 INTRODUCTION

Space Transportation System (STS-30) was launched from KSC on 4 May 1989. Two of the Redesigned Solid Rocket Motors (RSRM) were part of the launch system and are designated by RSRM-4A and RSRM-4B. The three field joints of both motors (total of six field joints) were protected by the Joint Protection Systems (JPS) (see Figure 1). The igniter heater was mounted on the igniter flange (see Figure 2). Figure 3 identifies the RSRM case configuration. The field joint heaters were turned on at L-8 hours and the igniter heater at L-24 hours to assure the joint O-ring and igniter seal temperatures were within the launch commit temperatures at the time of RSRM ignition. The purpose of the moisture seal is to prevent entry of rain into the joint while on the pad. The cork insulation provides thermal protection for the JPS during flight.

Following booster separation and splashdown, the motors were recovered and taken to hanger AF for inspection and disassembly. This inspection was performed per Post-Flight Engineering and Evaluation Plan (PEEP) TWR-16475, Vol. VII which outlines the basic evaluations to be performed at KSC Hanger AF.

2.0 OBJECTIVES

The objective of this report is to document the performance of the JPS and igniter heaters on the pad and the post-flight condition of the JPS components. This document will also discuss all observations which were written up as Squawks and/or Problem Reports (PRs).

The following objectives of TWR-19071, Morton Thiokol, Inc. Engineering Requirements Document for RSRM Typical Flight, are addressed in this report: (Numbers in parenthesis identify CEI specification paragraphs).

J. Certify the performance of the field joint heater and sensor assembly so that it maintains the case field joint at 75 °F minimum. Field joints shall not exceed 130 °F (3.2.1.11.a).

K. Certify that each field joint heater assembly meets all performance requirements (3.2.1.11.1.2).

3.0 CONCLUSIONS AND RECOMMENDATIONS

The JPS heaters performed per specification and maintained the field joint temperatures within the required temperature range at the time of motor ignition (3.2.1.11.a).

The LH Forward Field Joint Secondary Heater failed Dielectric Withstanding Voltage (DWV) test during the joint closeout prior to launch. This heater was not used since the primary heater functioned properly and maintained the required temperature. Post-test inspection revealed that pin A of the heater power cable was shorted to the connector shell.

Design changes have been implemented to resolve the heater power cable problem.

All field joint heater assemblies met all of the performance requirements (3.2.1.11.1.2).

4.0 RESULTS/DISCUSSIONS

4.1 Heater Control System

The KSC field joint heater temperature control system operated with a control band of 2 °F (set point temperature +/- 1 degree). Temperature expansions outside of this range were apparently the result of noise in the data system. The four temperature sensors at each field joint were continuously monitored and the coldest sensor was automatically selected for temperature control. The igniter control system operated within a control band of ± 5 °F. Both systems maintained the joint temperature within the required limits.

4.2 Post-Flight Inspection of the Joint Protection System

Evaluations of the JPS indicated the system performed as designed during flight.

4.2.1 Moisture Seal

A test of the vent valves on the STS-30 was conducted in the VAB after assembly which verified that all vent valves were closed. This confirms that the vent valves would not become a source of entry of rain water into the field joint while on the pad.

4.2.2 Cork External Insulation

All of the cork and ablative compound on the field joints was intact. Occasional pitting of the cork and paint was observed on those aft surfaces of cork that were exposed to nozzle severance and splashdown debris. Areas of darkened paint accompanied with blisters were also observed.

A crack in the extruded cork was found during open assessment on the right-hand forward field joint (see Figure 4). The exposed length ran 4.0 inches. The crack was approximately twice that size in the cork, but was bridged over with Hypalon paint. Dissection revealed a void under the crack running 5.0 inches circumferentially by 1.8 inches axially by 0.3 to 0.4 inch deep radially (see Figure 5). The void coincided with a carved out area in the cork at the 30-degree trunnion location.

Tables 1 through 7 are the post-test evaluation checkoff worksheets for the cork external insulation on the six field joints.

The aft and center field joints on the left-hand motor were dissected to assess the bond quality of the leading edge. The aft field joint had three significant voids with areas of 15, 60* and 58* in.^{2}. The center field joint had seven significant voids with areas of 34*, 11, 22*, 5*, 7, 4 and 14* in.^{2}. A typical area (34 in.^{2} intermittently) is shown in Figure 6. Tables 8 through 10 further document these voids.

The aft and center field joints on the left-hand motor were dissected to assess the bond quality between the extruded cork and the EPDM moisture seal/Kevlar straps. As seen in the past, large areas of void/unbond were seen between the Kevlar straps and the cork, especially on the forward straps. This appears to be the result of entrapped air forming a large, nearly full circumference void, between the Kevlar strap and the extruded cork. Other voids were also documented. Tables 11 through 25 document the status of the vent holes which were drilled in the cork.

4.2.3 Heaters and Sensors

The heaters and sensors functioned normally and maintained the specified joint temperatures.

The heaters and the sensor assemblies were not available for inspection except as shredded pieces after removal by water laser. The pieces examined showed no signs of overheating, discoloration, or delamination.

*intermittent voids

Figures 7 through 9 are plots of the temperature of the four RTDs of each of the three field joints of the left SRM and Figures 10 through 12 are plots of the RTDs of the right SRM. The ambient temperature air is overlaid on the temperature plots. TWR 17543 provides an explanation for some of the observed temperature exursions.

The post-flight inspection of the left-hand secondary heater system isolated the problem to the cable. The conductor on pin A was shorted to the connector back shell. This section of cable was sent to the Malfunction Analysis Branch (MAB) where an investigation has been completed. The investigation report, MAB104, is attached as Appendix A.

4.2.4 Heater Power and Sensor Cables

All of the cables of the JPS system were embedded in K5NA. The K5NA was visually inspected and found to have survived the flight in excellent condition. There was no evidence of voids or missing material, debonds, charred material, or impact damage. Tables 26 and 27 are the post-test evaluation worksheets for the heater cables.

4.2.5 Igniter Heater

The igniter heater installation on each motor was intact and secure. Figures 13 and 14 are the plots of the temperature at the igniter adapter. Table 28 is the evaluation checkoff worksheet for the igniter heater installation. Table 29 is the evaluation checkoff worksheet for the igniter heater components.

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APPENDIX A

Malfunction Analysis Branch Report
MAB-104-89

SRB Forward Joint Heater Power Cable Failure Analysis

NASA

DIRECTOR OF ENGINEERING DEVELOPMENT

DIRECTOR, MECHANICAL ENGINEERING

MATERIALS SCIENCE LABORATORY

MALFUNCTION ANALYSIS BRANCH

DM-MSL-3, ROOM 2217, O&C BUILDING

KENNEDY SPACE CENTER, FLORIDA 32899

MAB-104-89

JUNE 23, 1989

SUBJECT: SRB Forward Joint Heater Power Cabling Failure Analysis

1.0 FOREWORD

1.1 Prior to the flight of STS 30R, the forward joint redundant heater failed a ramped 1500 volt DC Dielectric Withstand Voltage Test (DWV).

1.2 Post flight testing indicated that connector X22W802/P1 was most likely the cause of the preflight anomaly although other cable segments indicated faults. All cable segments identified as anomalous were sent by Lockheed Space Operations Company (LSOC) personnel to the Malfunction Analysis Branch (MAB) for evaluation.

2.0 INVESTIGATIVE PROCEDURES AND RESULTS

2.1 It was suspected that the cabling submitted to the MAB was contaminated with salt water and salt residue as a result of the SRB flight recovery operation. The subject cabling was subjected to a drying procedure which consisted of being placed in an environmental chamber at reduced pressure. This depressurized condition was maintained for several hours. The cables were then submerged in demineralized water and thoroughly rinsed of salt residue. The cables were again submitted to vacuum.

2.2 Analysis of the cables after the drying process indicated that only the cable segment containing connector X22W802/P1 had a verifiable anomaly.

This anomaly was a high resistance path from pin "A" to Shield. This segment of cable is shown in Figure 1.

2.3 Connector X22W802/P1 and connector X22A50 P2/J2 were fluoroscopically examined. No anomalies were noted.

2.4 The cable segment containing connector X22W802/P1 was evaluated using both a Hewlett Packard (HP) 3478 multimeter (accurate to 30 Megohms) and a General Radio (GENRAD) Megohm Bridge model 1044-A. Readings from the GenRad bridge indicated that at voltage levels up to 200 volts DC the cable anomaly measured slightly greater than 3.5 Megohms. Above 500 volts DC the anomaly indicated less than 1 Kohm.

2.5 Connector X22A50/P2 was then removed from the cable assembly and the presences of the anomaly checked as described in paragraph 2.4.

2.6 While observing the indication of the anomaly, using the previously described test equipment, the cabling was flexed/manipulated in an attempt to isolate the area of concern. This procedure indicated that the cabling below the "Y" (towards connector X22A50/P1) was unrelated to the anomaly. This segment of cabling was separated and the presence of the anomaly again confirmed.

2.7 The remaining segment of cabling was again fluoroscoped looking closely for indications of some type wire-to-shield anomaly. No irregularities were noted.

2.8 At this point a careful dissection of the remaining cable assembly was undertaken. Figure 2 depicts the result of shield removal. After the shield was removed the anomaly was again verified. The top backshell nut was removed without affecting the anomaly and all unrelated conductors were severed (See Figure 3).

2.9 The connector was then examined fluoroscopically and a typical radiographic view is shown in Figure 4. Note that the wire conductor corresponding to pin "A" appears to be pressed against the inner wall of the backshell. The lower view in Figure 4 shows the inner backshell highlighted.

2.10 The remainder of the backshell was removed exposing the underlying Stycast material and conductors. This area was examined using a low power stereomicroscope. Figure 5 illustrates the anomaly located against the inner wall of the backshell. Figure 6 shows a magnified view of the anomaly and the arrow in the lower view indicates a melted strand of the wire conductor.

3.0 DISCUSSION

3.1 The anomaly examination described in paragraph 2.10 indicated two items of interest. The first of these items was that the area of concern appeared slightly charred or carbonized. This anomaly is most likely related to the number of times the connector (and pin "A" in particular) was exposed to DWV.

3.2 The second item of interest related to the actual surface geometry of the anomaly. It appears that a thin (flap) segment of the conductor insulation was peeled back as a result of insertion into the connector backshell. This anomaly may have been caused by a nick in the insulation (from assembly or handling) which was then scraped against the edge of the inner backshell wall. Regardless of the method, the underlying insulation was either thinned or removed exposing the wire conductors. This exposure resulted in failing DWV.

4.0 CONCLUSION

The connector failed DWV due to a manufacturing anomaly. This anomaly consisted of damaged insulation on the conductor corresponding to pin "A" and was fixed (using a Stycast potting compound) against the interior of the connector backshell.

INVESTIGATOR: Lawrence L. Ludwig
LAWRENCE L. LUDWIG

APPROVED:
C. R. DENABURG

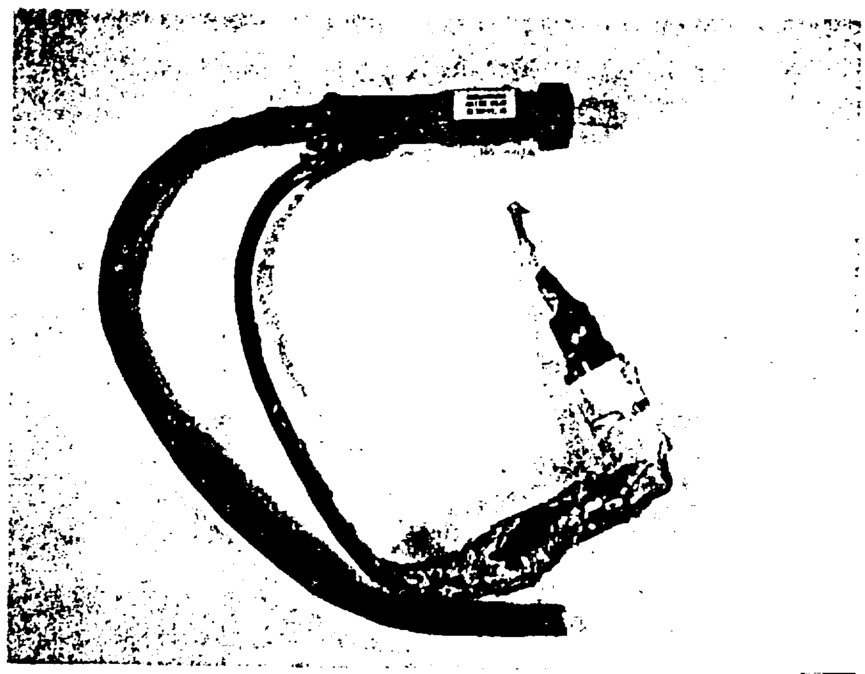

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FIGURE 1

PHOTOGRAPH OF CABLE SEGMENT "AS RECEIVED".
MAGNIFICATION: 3X

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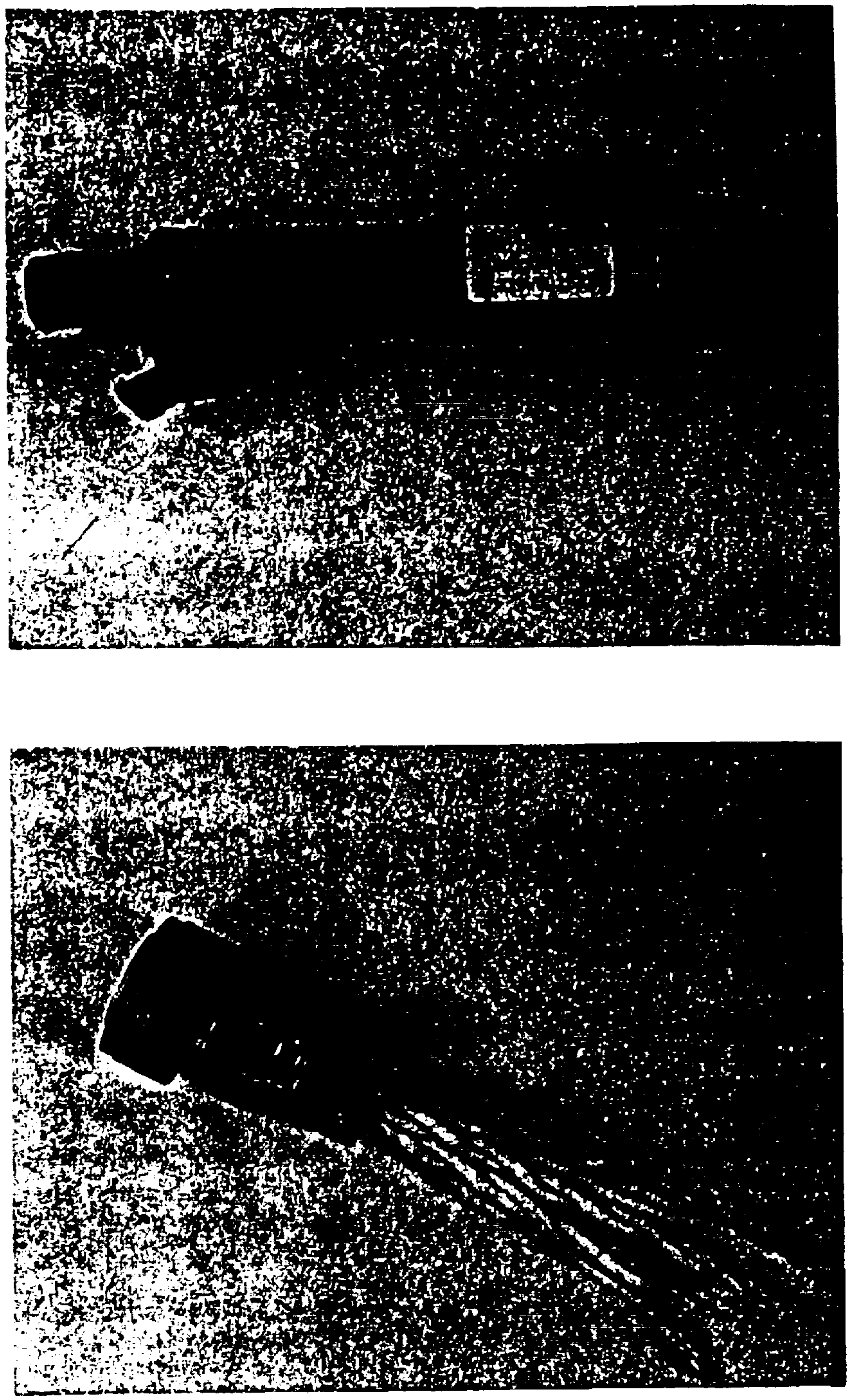

FIGURE 2

PHOTOGRAPH OF THE ANOMALOUS CABLE SEGMENT WITH AND WITHOUT SHIELD AND OUTER JACKET.
MAGNIFICATION: BOTH 6X

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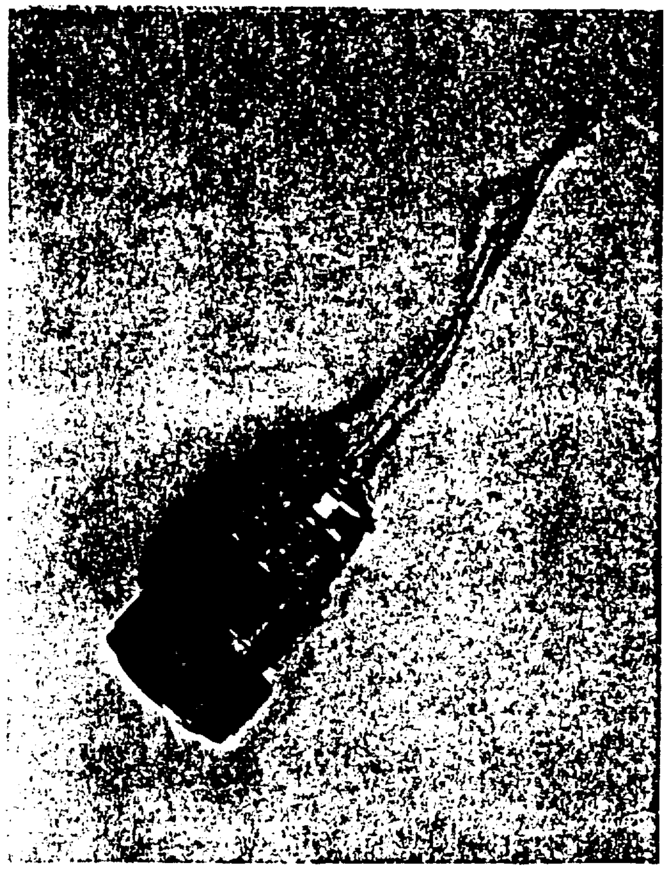

FIGURE 3

PHOTOGRAPH OF ANOMALOUS CONNECTOR WITH UNRELATED CONDUCTORS REMOVED.

MAGNIFICATION: 0.6X

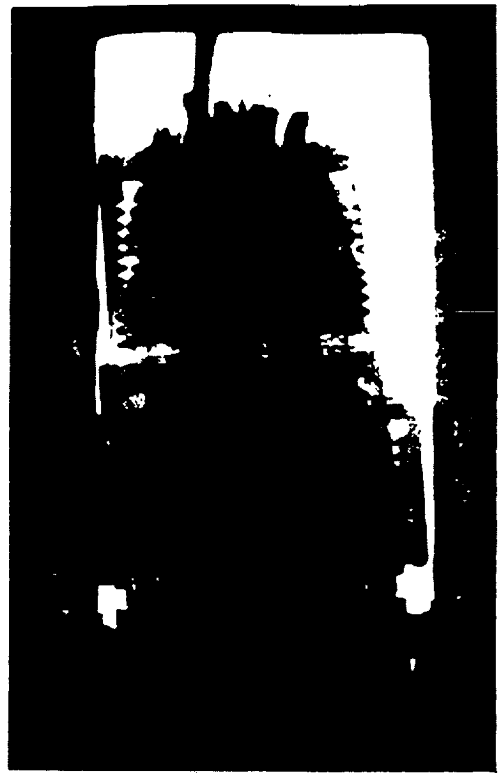

FIGURE 4

RADIOGRAPHS OF ANOMALOUS CONNECTOR DEPICTING THE POSITION OF THE CONDUCTOR CORRESPONDING TO PIN "A".
MAGNIFICATION: BOTH 1.5X

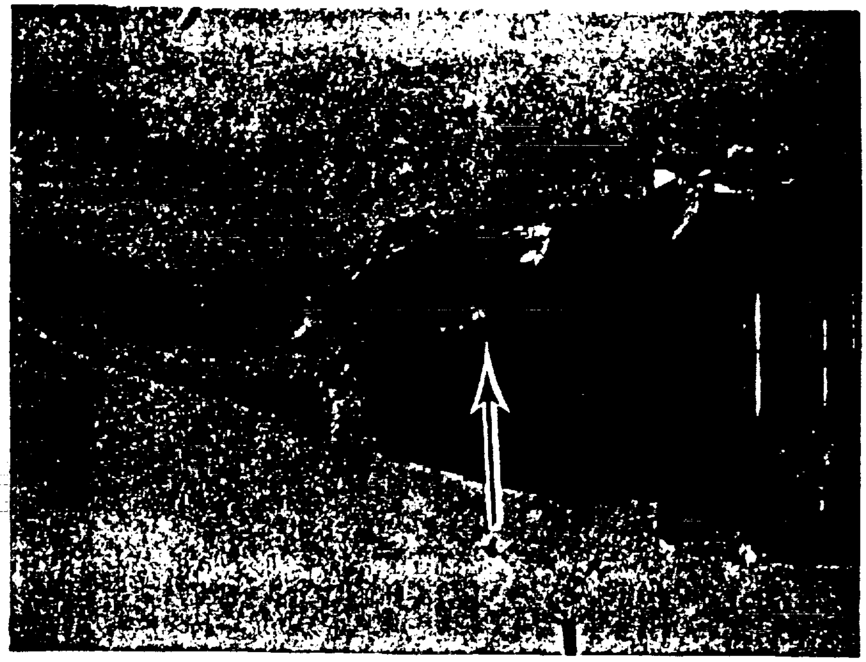

FIGURE 5

PHOTOGRAPH OF THE CONNECTOR ANOMALY.
MAGNIFICATION: 1.9X

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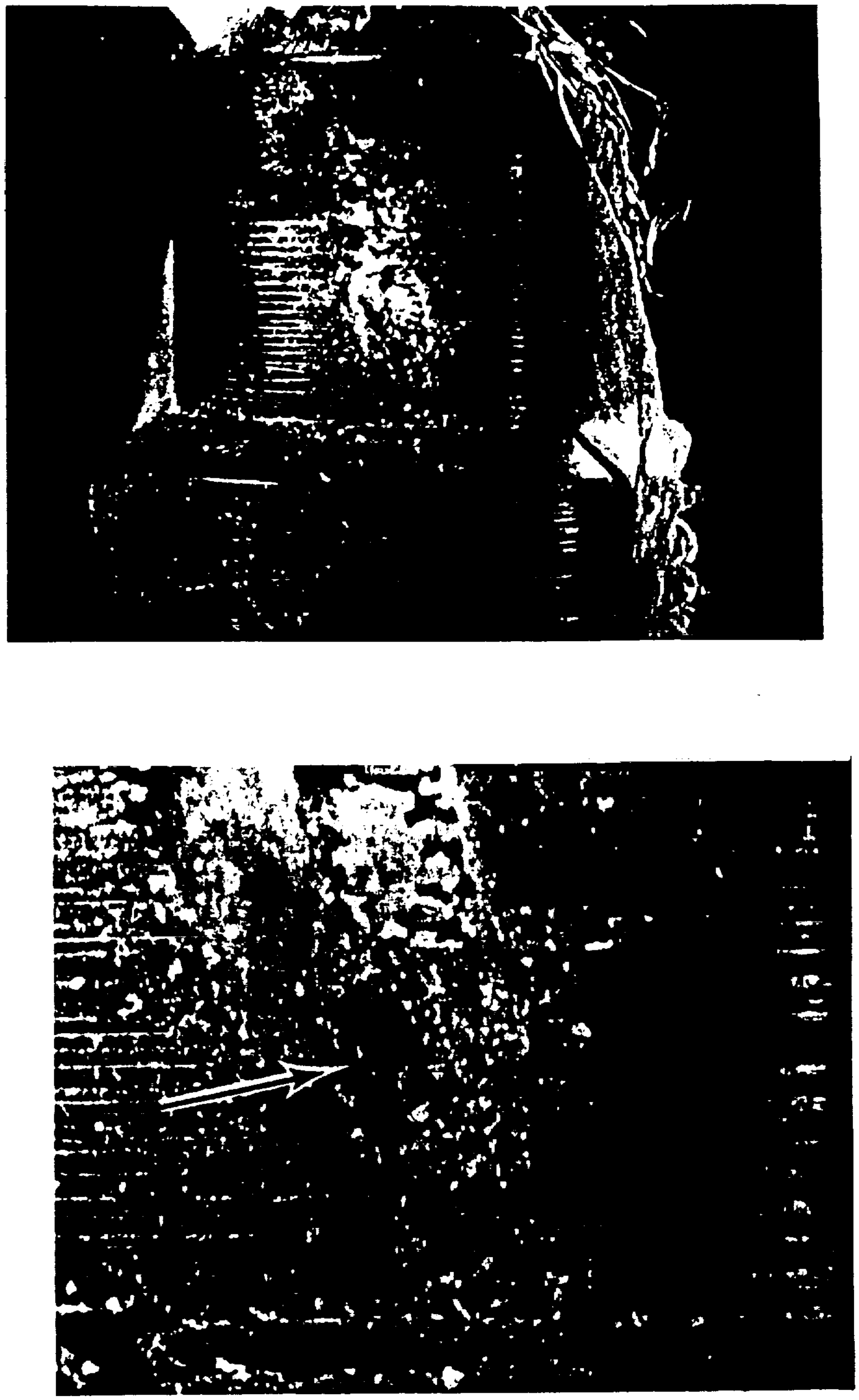

FIGURE 6

MAGNIFIED VIEW OF THE CONNECTOR ANOMALY.
MAGNIFICATION: UPPER 4.3X
LOWER 14X

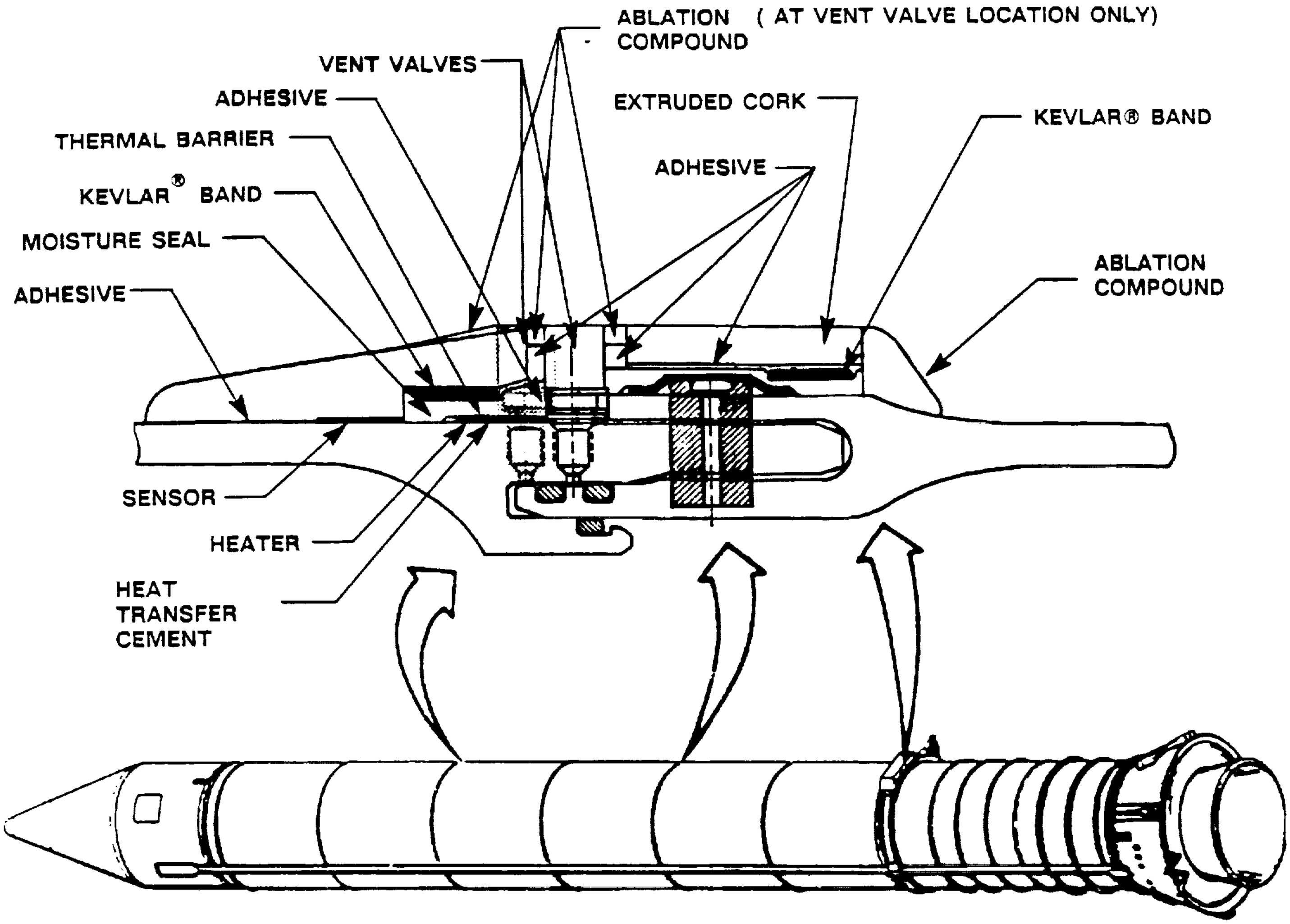

Figure 1 Field Joint Protection Configuration

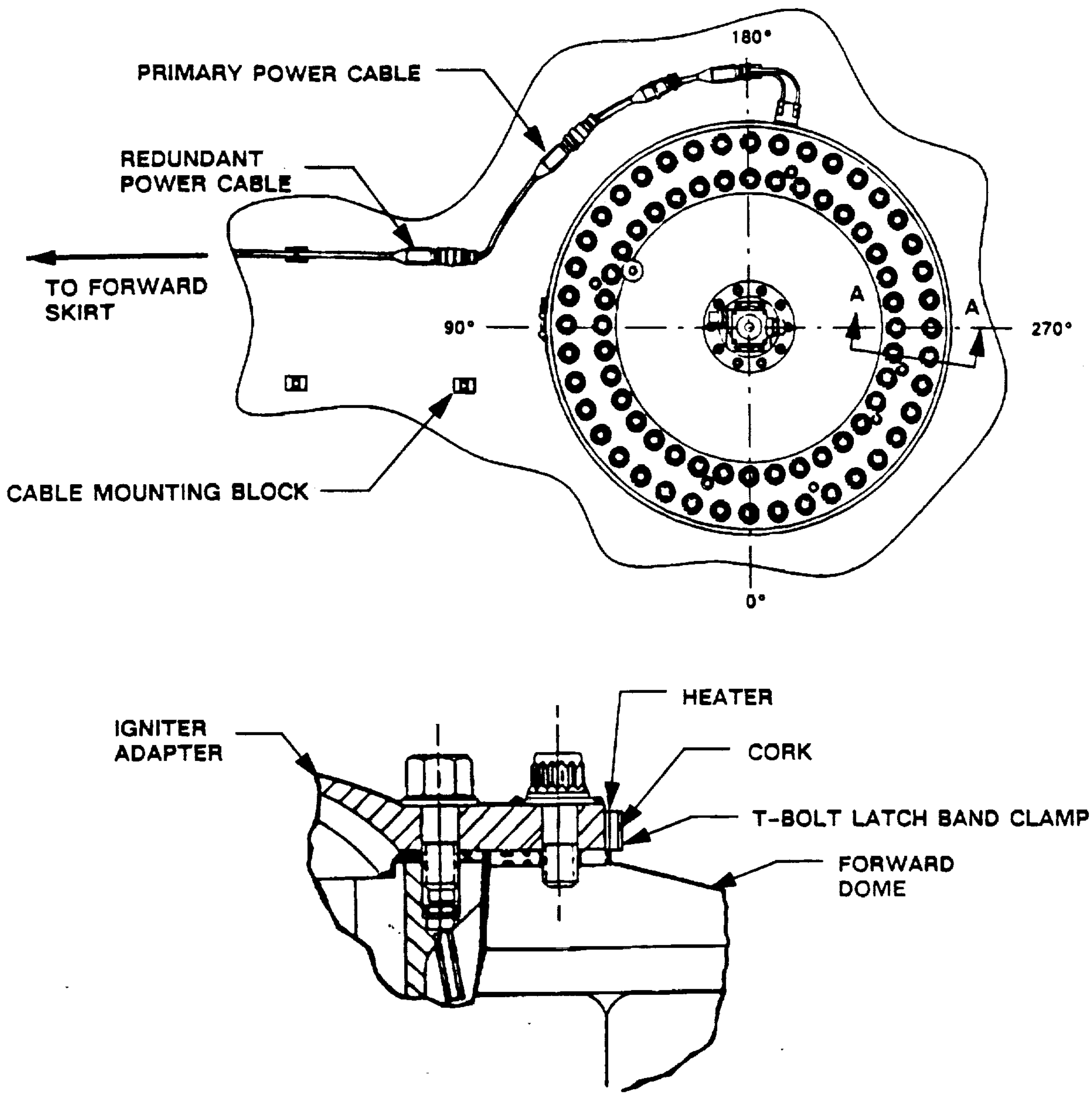

Figure 2 Igniter Joint Heater Configuration

JOINTS

FIELD	FACTORY
1491.5	1817.6
1171.5	1697.5
851.5	1577.5
	1331.5
	1011.5
	691.5
	531.5

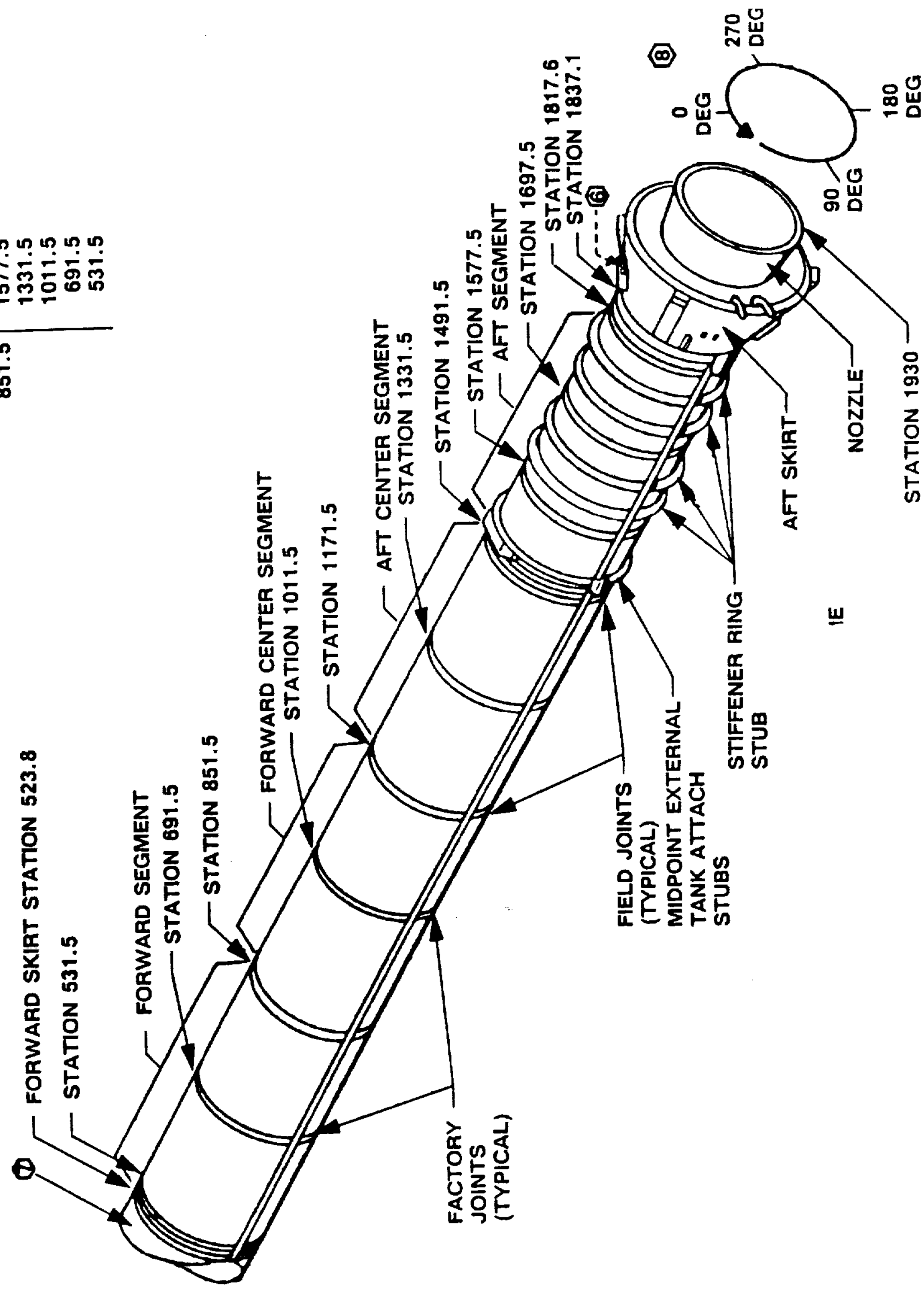

Figure 3 RSRM Case Configuration and Relationship

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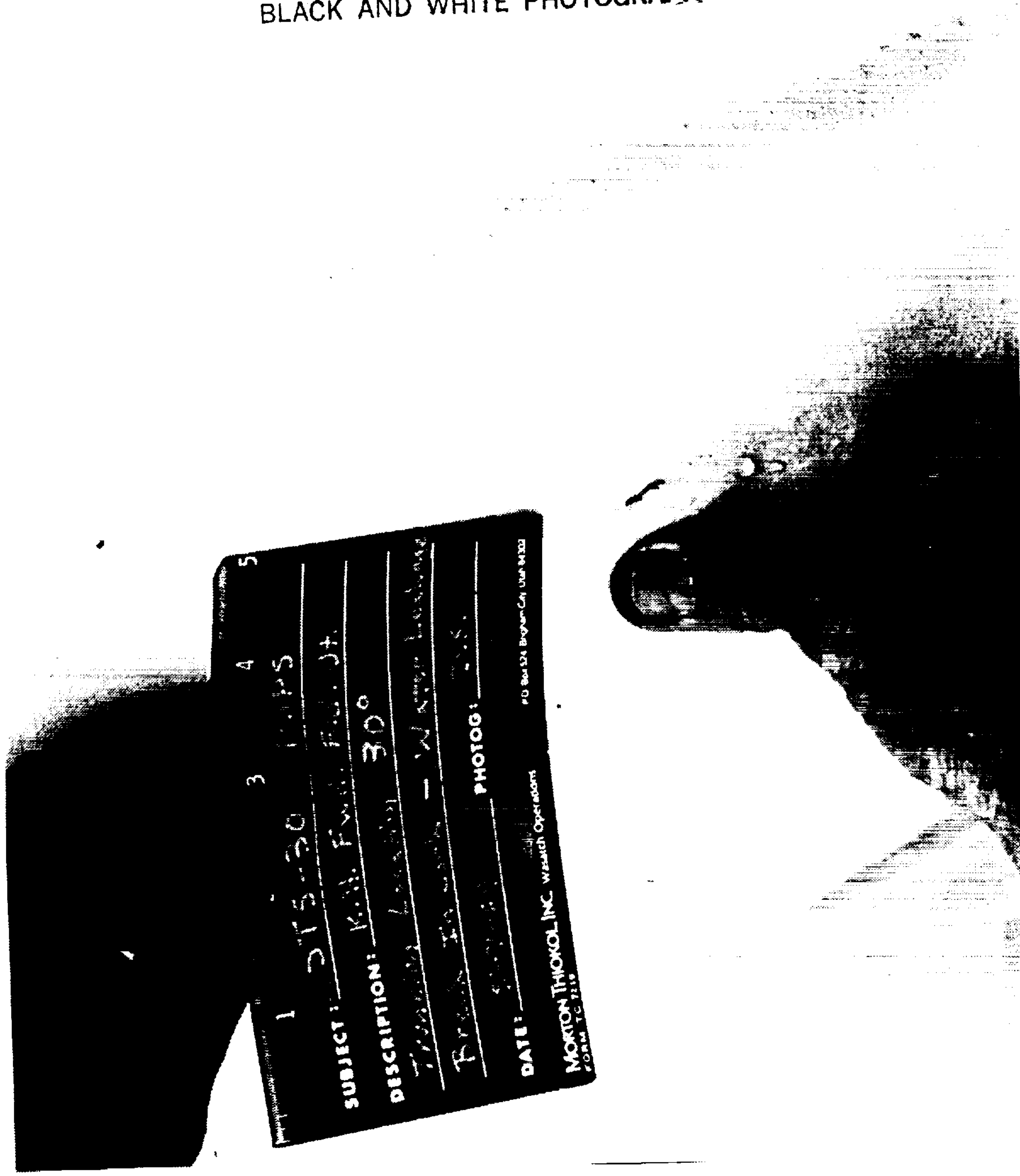

Figure 4 Crack in Cork on Right Toward Field Joint

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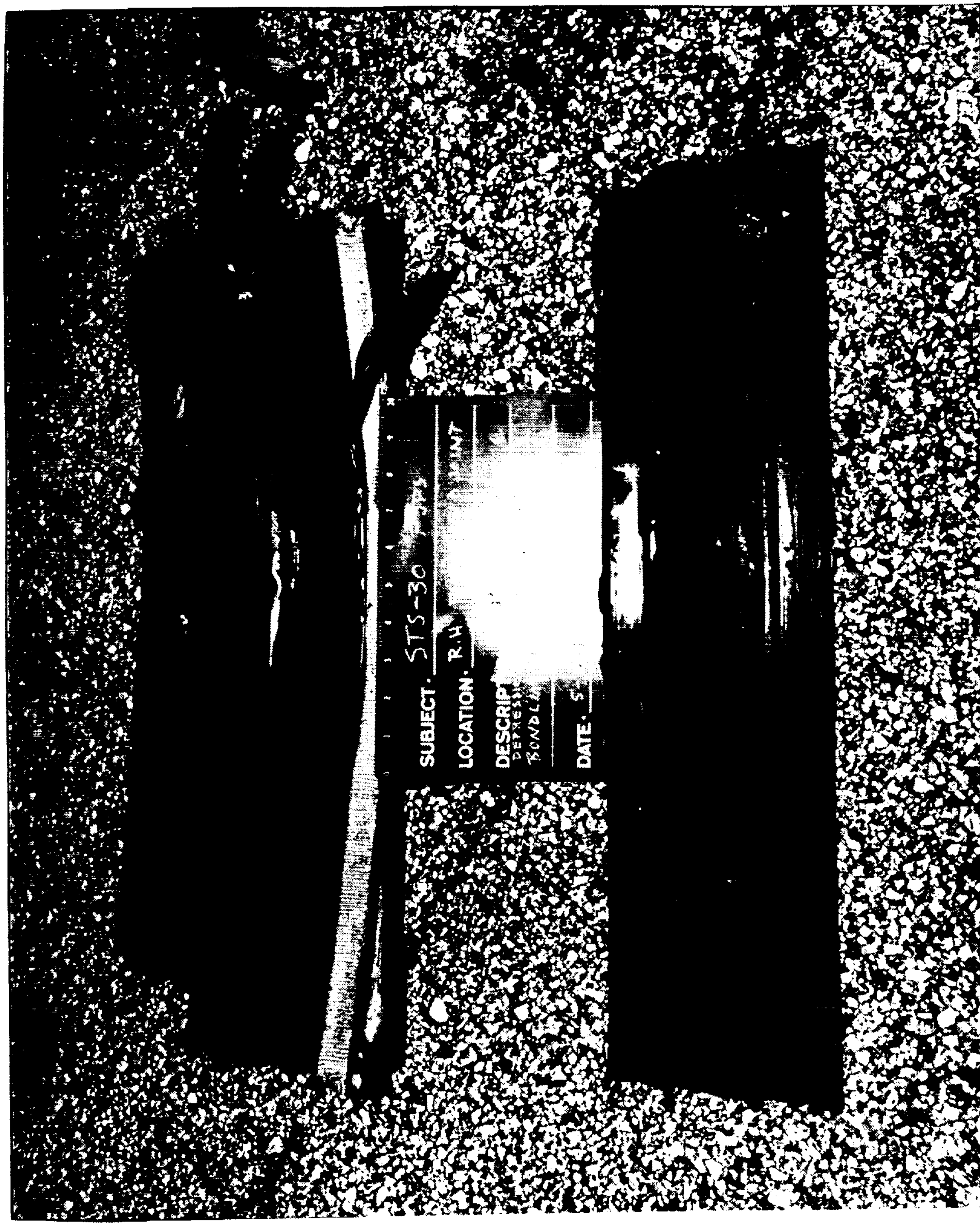

Figure 5 Void under Crack in Cork, Right Toward Field Joint

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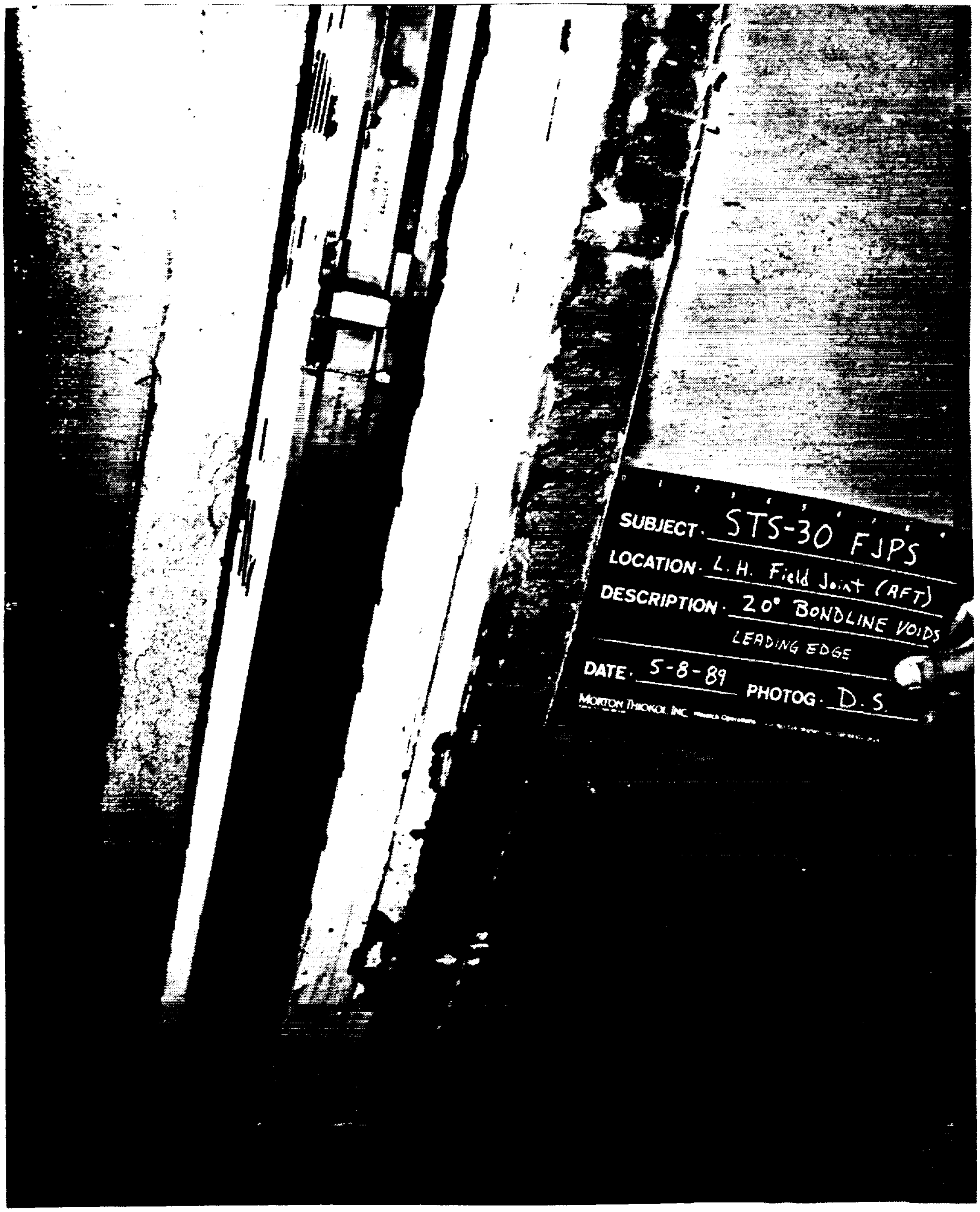
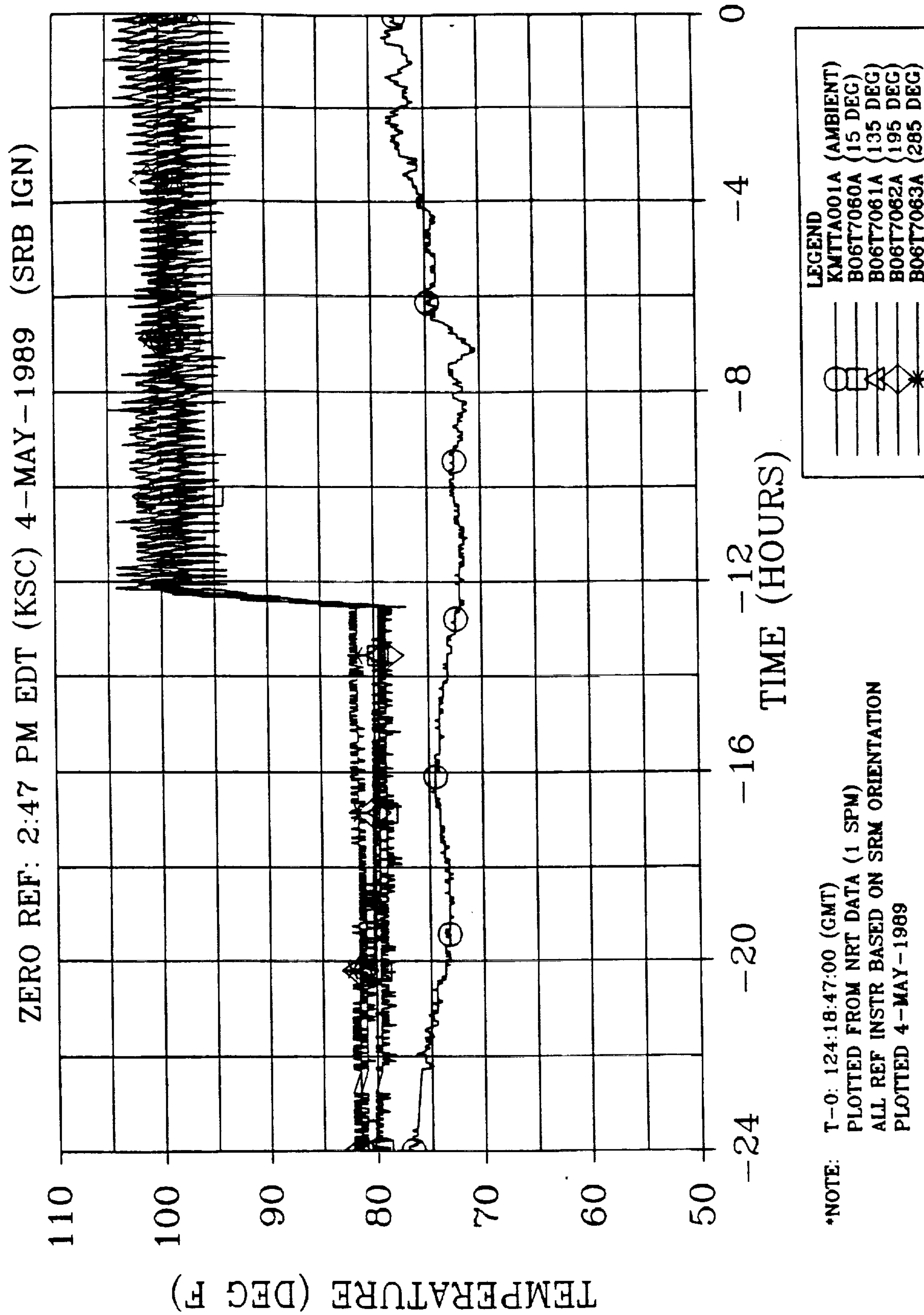


Figure 6 Debond under Leading Edge, Left Aft Field Joint



*NOTE: T-0: 124:18:47:00 (GMT)
PLOTTED FROM NRT DATA (1 SPM)
ALL REF INSTR BASED ON SRM ORIENTATION
PLOTTED 4-MAY-1989

Figure 7 Left SRM Fwd Field Joint Temperature Overlaid with Ambient

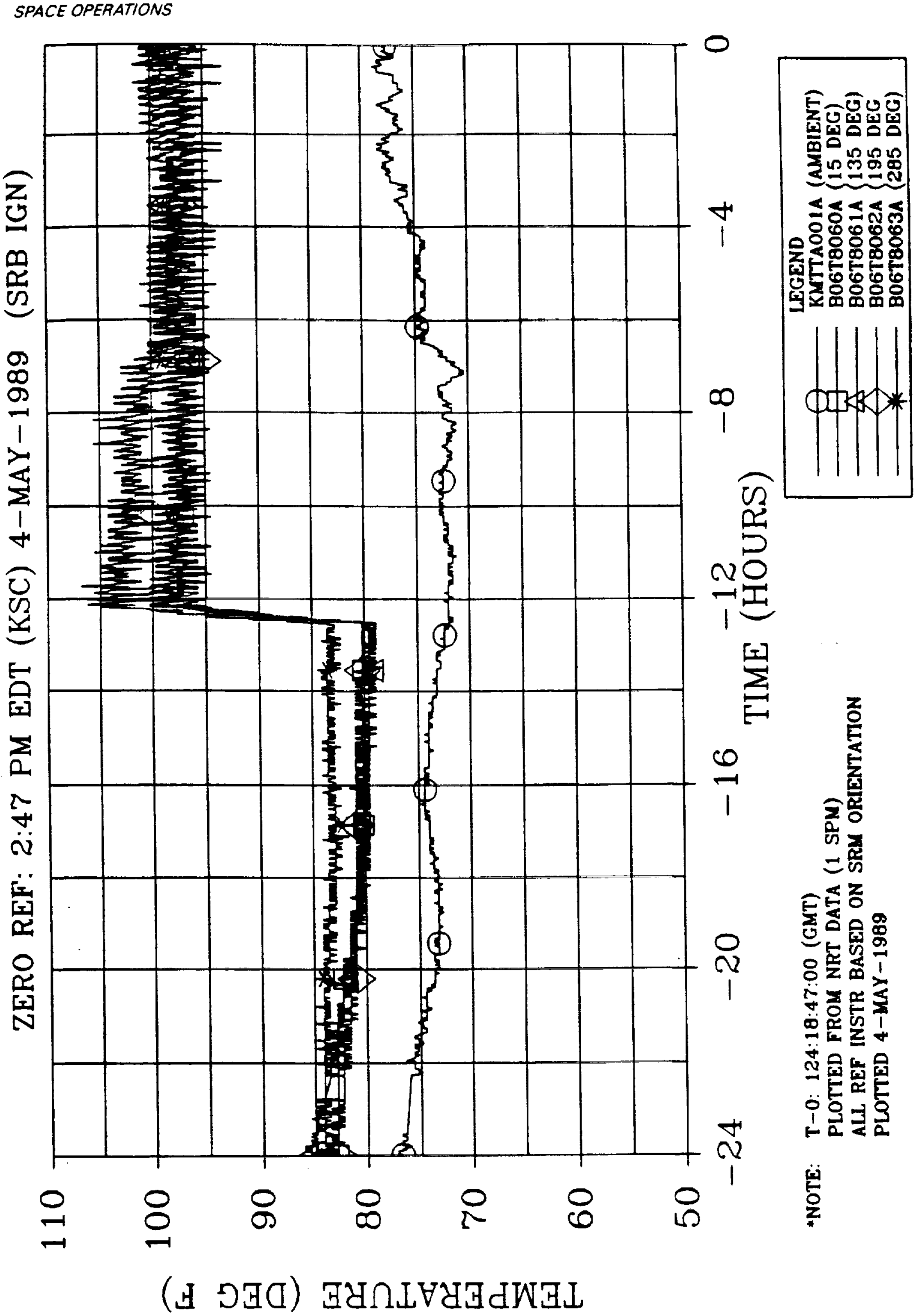


Figure 8 Right SRM Fwd Field Joint Temperature Overlaid with Ambient

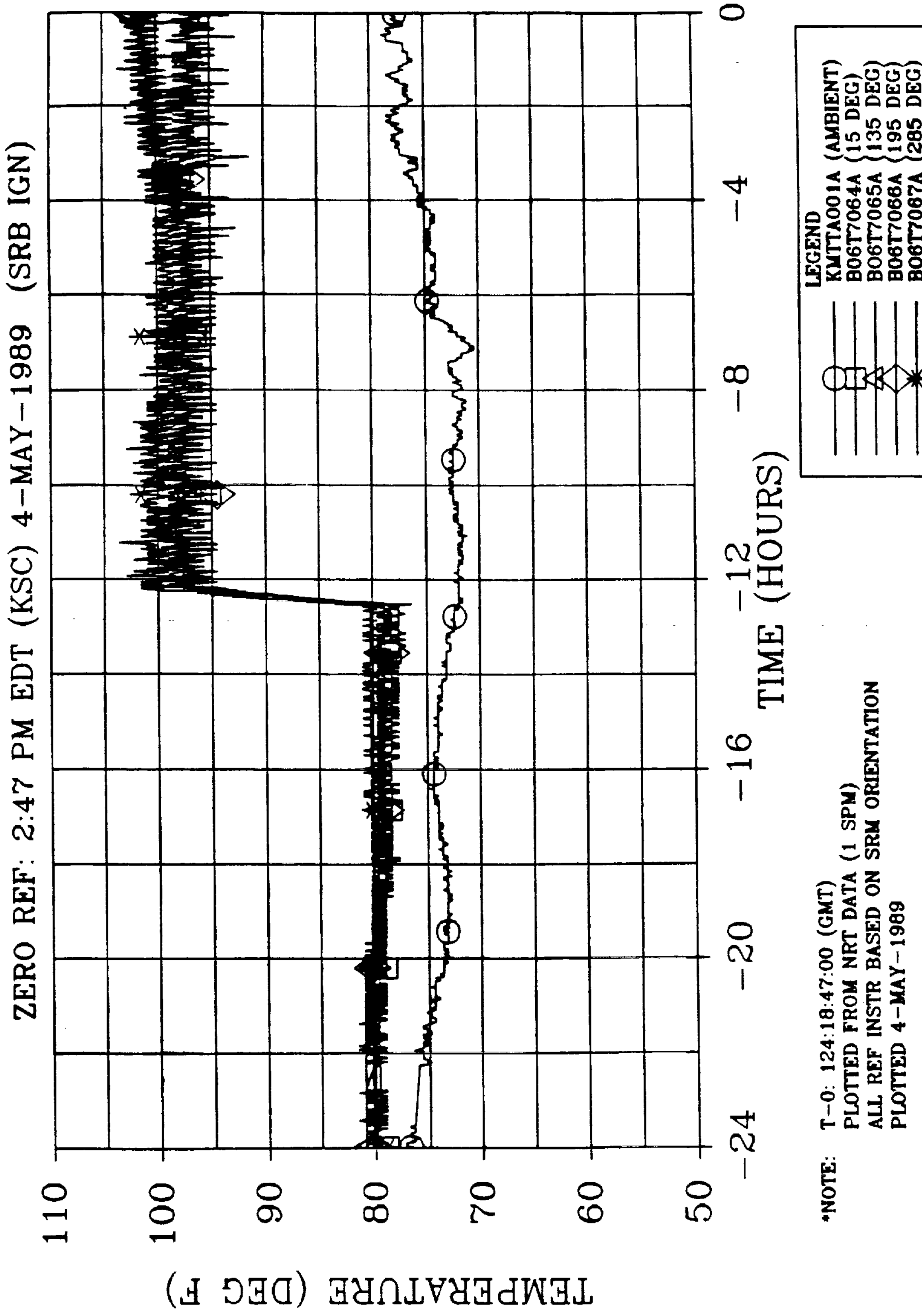


Figure 9 Left SRM Cntr Field Joint Temperature Overlaid with Ambient

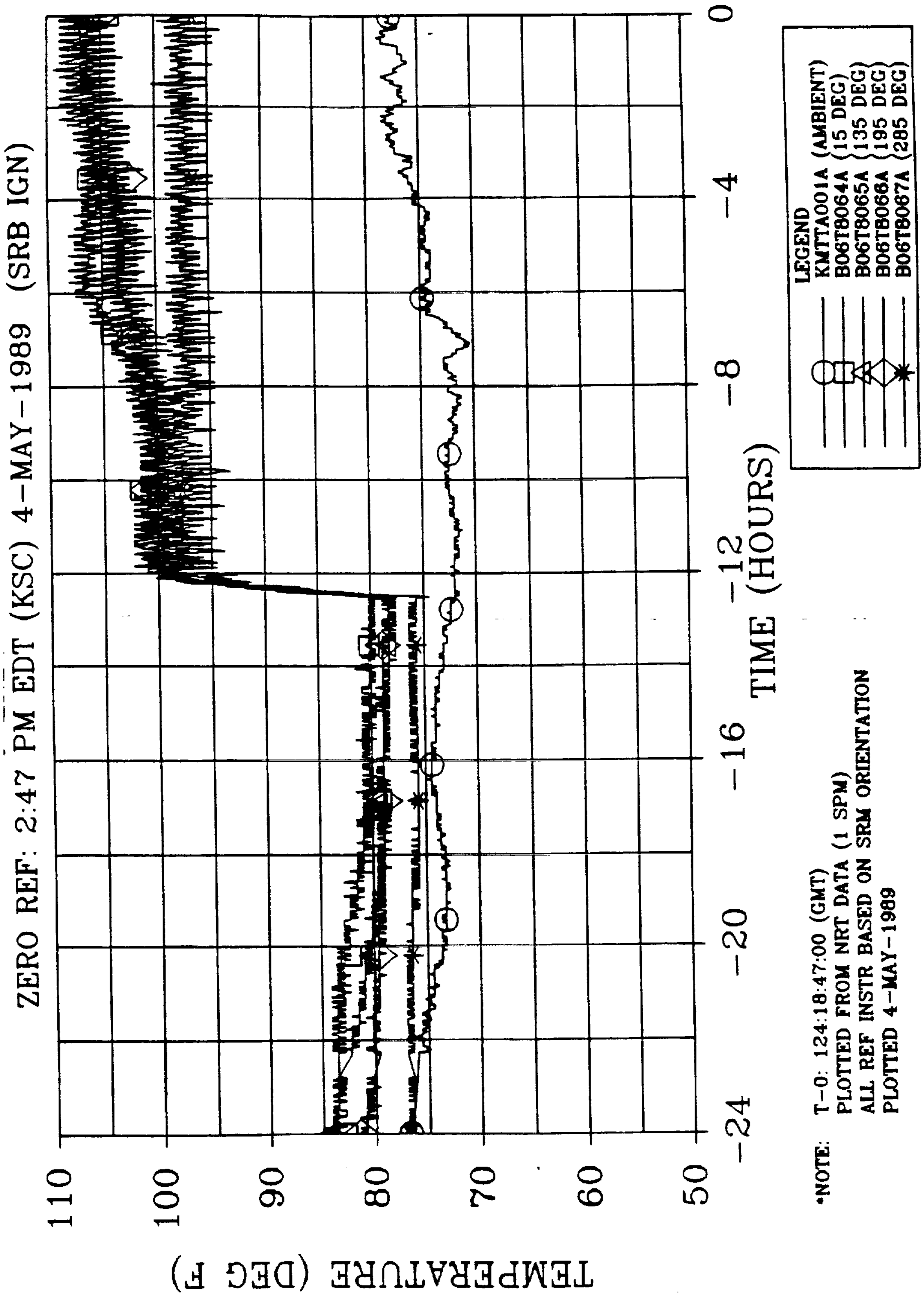


Figure 10 Right SRM Cntr Field Joint Temperature Overlaid with Ambient

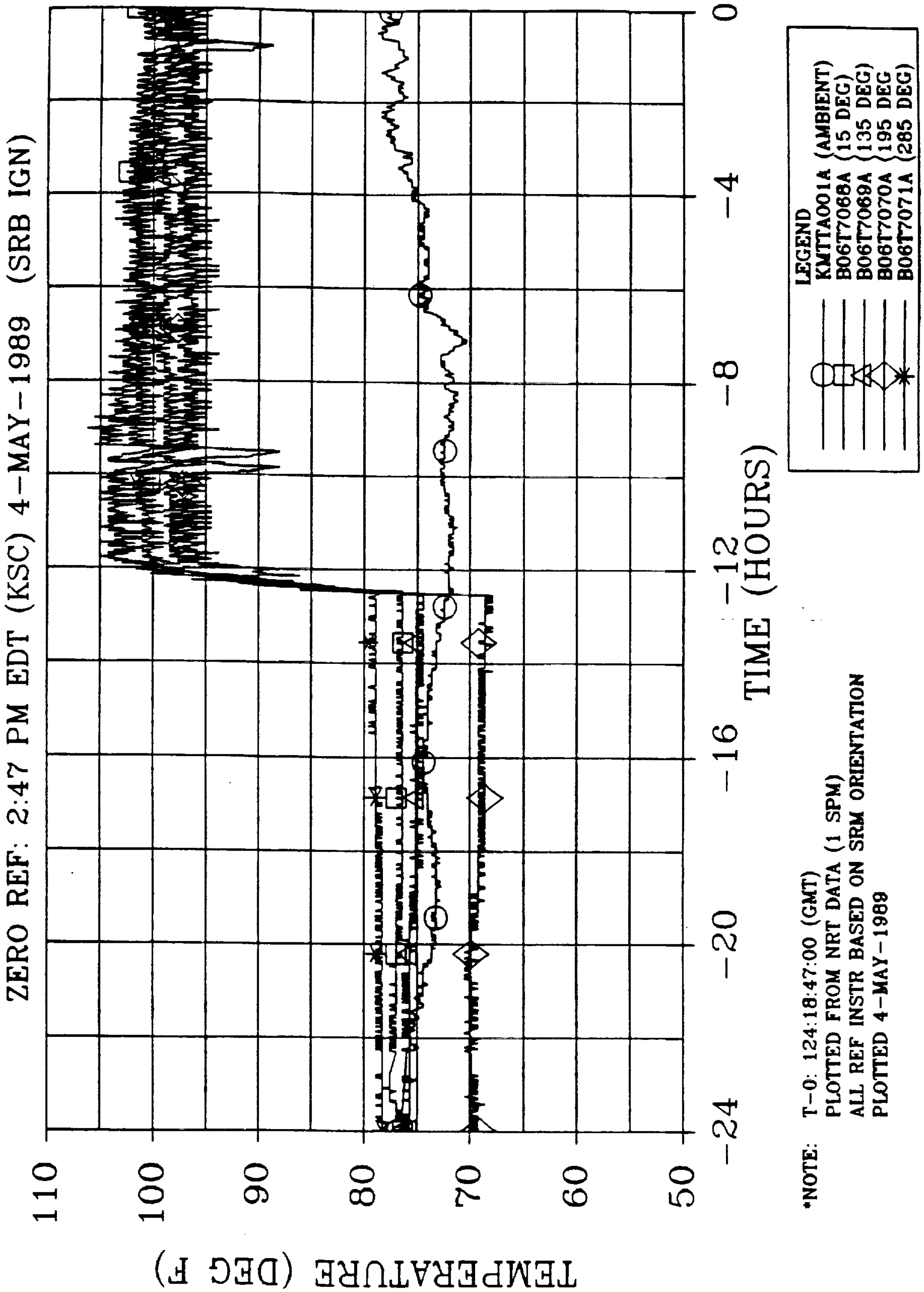


Figure 11 Left SRM Aft Field Joint Temperature Overlaid with Ambient

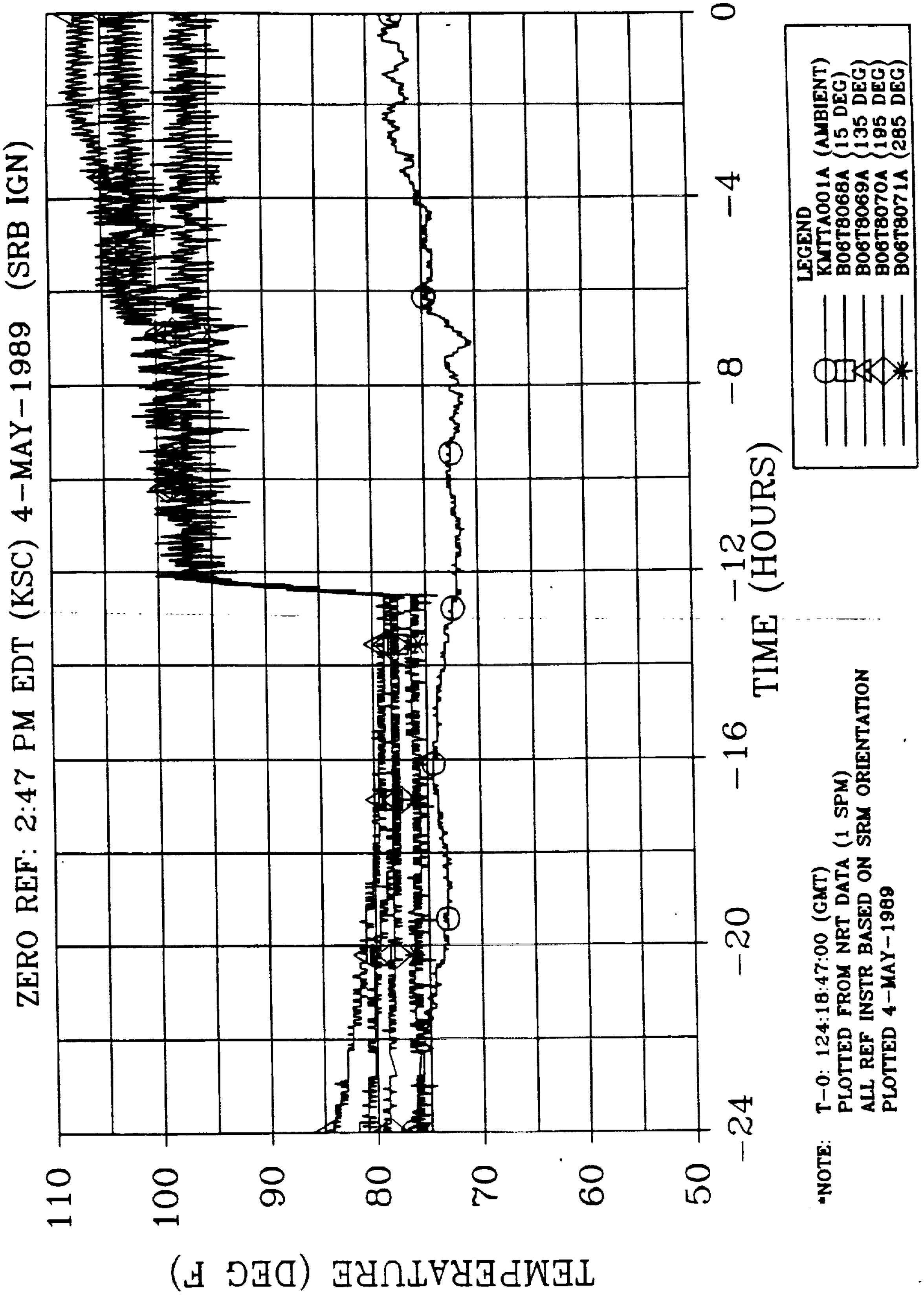


Figure 12 Right SRM Aft Field Joint Temperature Overlaid with Ambient

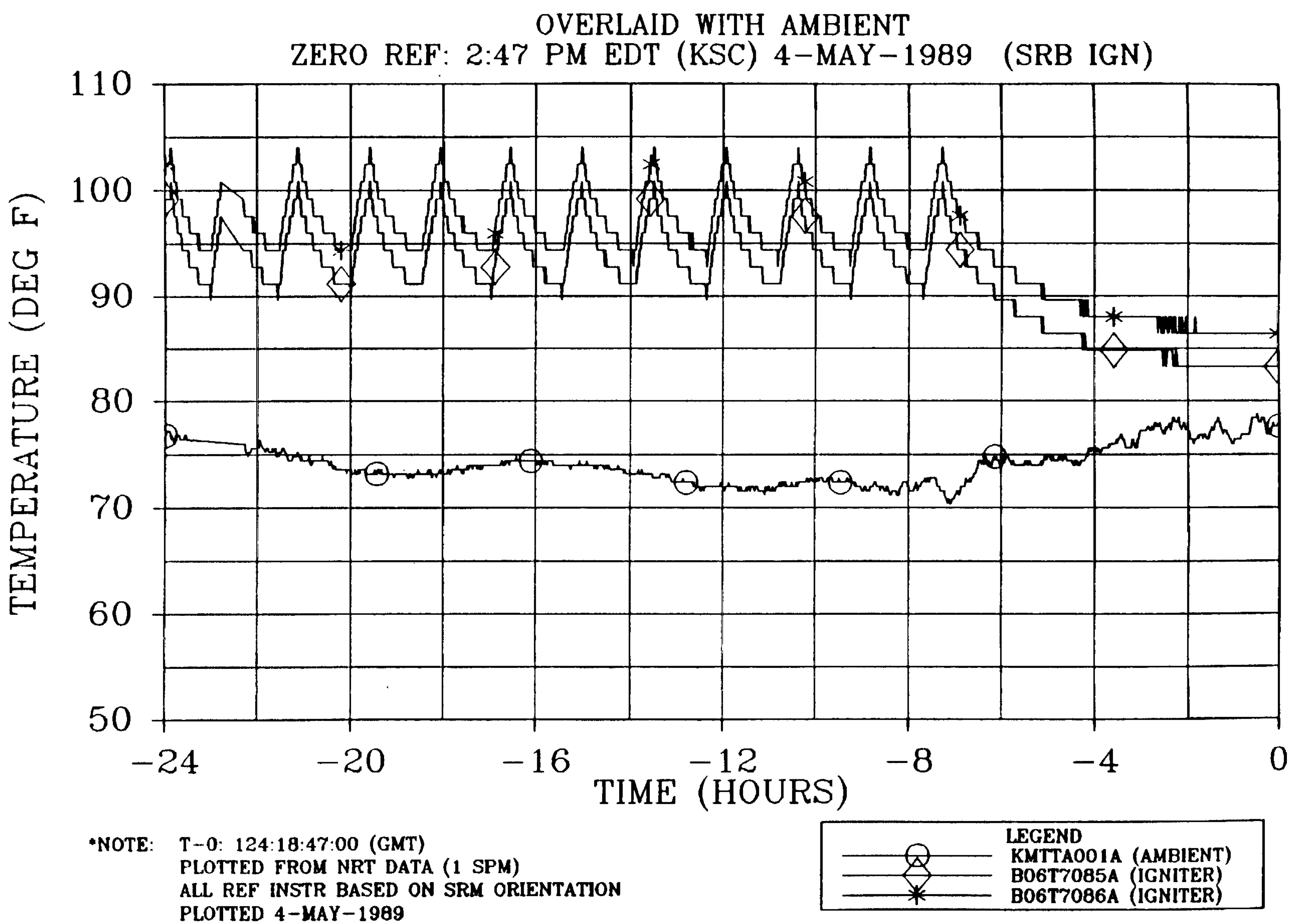


Figure 13 Left SRM Igniter Joint Temperature Overlaid with Ambient

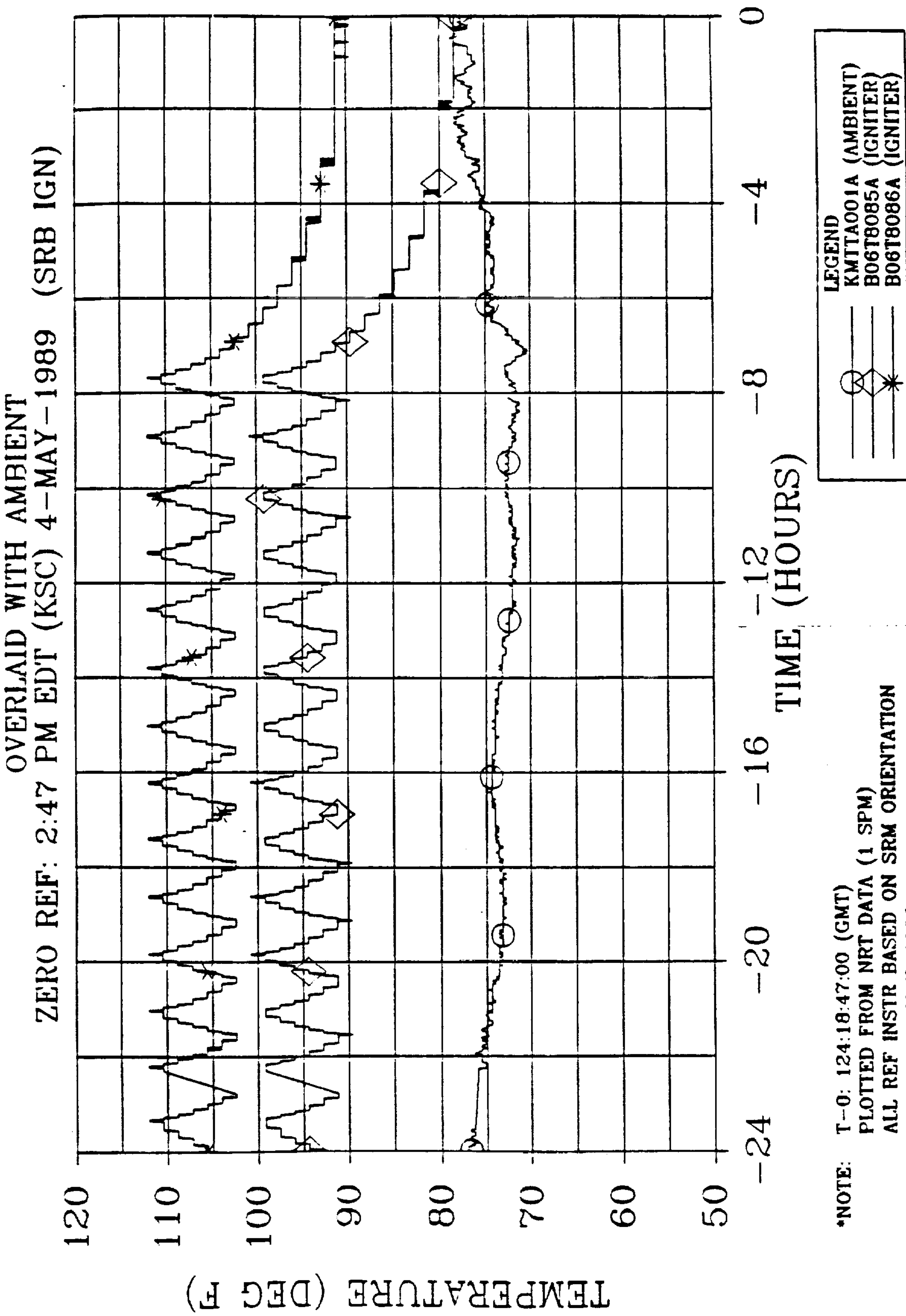


Figure 14 Right SRM Igniter Joint Temperatures Overlaid with Ambient

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Table 1
Field Joint External Insulation Condition - Evaluation Checkoff Worksheet

Inspector(s): Mark Perry

Motor No.: STS-30 | Side: ☒ Left ☐ Right | Date: 7 May 1989

Field Joint: ☒ Forward (FWD) ☐ Center (CTR) ☐ Aft (AFT)

Component: JPS

I. External Cork Insulation

A. Voids or Missing Material >0.7 cu.in. (TPSVD)? ____ yes ✓ no

B. Debonds (DEBND)? ____ yes ✓ no

C. Charred Material (HTAFF)? ____ yes ✓ no

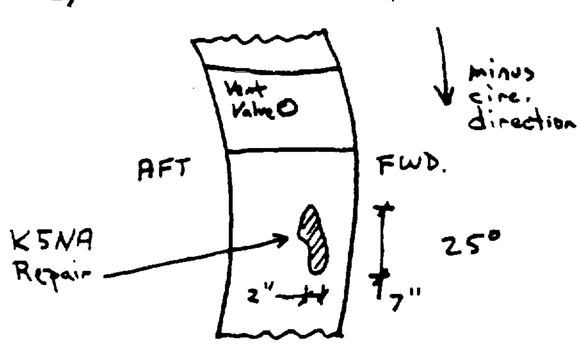
If any of the above conditions exist, note:

Condition (Observation Code)	Axial Location (Station) (In.)	Starting Degree Location (Deg.)	Ending Degree Location (Deg.)	Circumferential Width (In.)	Axial Length (In.)	Radial Depth (In.)

Notes / Comments

1) K5NA repairs, 1.5 in. diameter, on the leading edge where pull tests were performed pre-flight. (Repairs at 60°, 150°, 240°, and 330°).

2) [redacted] Cork repairs were noted at 25° and 120°:



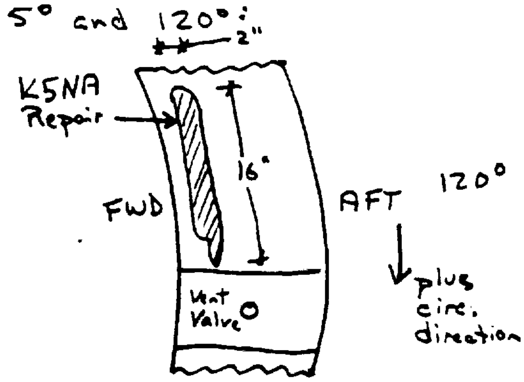


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Table 2
Field Joint External Insulation Condition - Evaluation Checkoff Worksheet

Inspector(s): Mark Perry

Motor No.: STS-30 | Side: ☒ Left ☐ Right | Date: 7 May 1989

Field Joint: ☐ Forward (FWD) ☒ Center (CTR) ☐ Aft (AFT)

Component: JPS

I. External Cork Insulation

A. Voids or Missing Material >0.7 cu.in. (TPSVD)? ___ yes ✓ no

B. Debonds (DEBND)? ___ yes ✓ no

C. Charred Material (HTAFF)? ___ yes ✓ no

If any of the above conditions exist, note:

Condition (Observation Code)	Axial Location (Station) (In.)	Starting Degree Location (Deg.)	Ending Degree Location (Deg.)	Circumferential Width (In.)	Axial Length (In.)	Radial Depth (In.)

Notes / Comments

1) K5NA repairs, 1.5 in. diameter, on the leding edge where pull tests were performed pre-flight (Repairs at 60°, 150°, 240°, and 330°).

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Table 3
Field Joint External Insulation Condition - Evaluation Checkoff Worksheet

Inspector(s): Mark Perry

Motor No.: STS-30 | Side: ☒ Left ☐ Right | Date: 7 May 1989

Field Joint: ☐ Forward (FWD) ☐ Center (CTR) ☒ Aft (AFT)

Component: JPS

I. External Cork Insulation

A. Voids or Missing Material >0.7 cu.in. (TPSVD)? ____ yes ✓ no

B. Debonds (DEBND)? ____ yes ✓ no

C. Charred Material (HTAFF)? ____ yes ✓ no

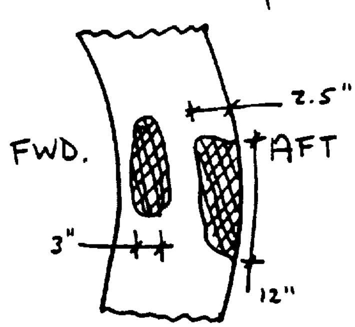
If any of the above conditions exist, note:

Condition (Observation Code)	Axial Location (Station) (In.)	Starting Degree Location (Deg.)	Ending Degree Location (Deg.)	Circumferential Width (In.)	Axial Length (In.)	Radial Depth (In.)

Notes / Comments

1) K5NA repairs, 1.5 in. diameter, on the leading edge where pull tests were performed pre-flight. (Repairs at 60°, 150°, 240°, and 330°).

2) Two other cork repairs were noted at 335°



REVISION ___

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Table 4
Field Joint External Insulation Condition - Evaluation Checkoff Worksheet

Inspector(s): Mark Perry

Motor No.: STS-30 | Side: ☐ Left ☒ Right | Date: 7 May 1989

Field Joint: ☒ Forward (FWD) ☐ Center (CTR) ☐ Aft (AFT)

Component: JPS

I. External Cork Insulation

A. Voids or Missing Material >0.7 cu.in. (TPSVD)? ____ yes ✓ no

B. Debonds (DEBND)? ____ yes ✓ no

C. Charred Material (HTAFF)? ____ yes ✓ no

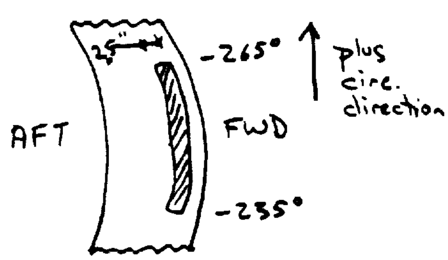
If any of the above conditions exist, note:

Condition (Observation Code)	Axial Location (Station) (In.)	Starting Degree Location (Deg.)	Ending Degree Location (Deg.)	Circumferential Width (In.)	Axial Length (In.)	Radial Depth (In.)

Notes / Comments

1) K5NA repairs, 1.5 in. diameter, on the leading edge where pull tests were performed pre-flight (Repairs at 60°, 150°, and 330° - The 240° location coincided with a larger repair area)

2) Another cork repair was noted:



(continued on OCF)

Thiokol CORPORATION
SPACE OPERATIONS

Table 5
Observation Clarification Form

Motor No. STS-30   Inspector(s) Mark Perry

☐ Left (A) ☒ Right (B)   Date 7 May 1989

Segment: ☒ Forward ☒ Forward Center ☐ Aft Center ☐ Aft ☐ Nozzle

Joint: Forward Field Joint   Case End: NA

Location: Axial (in.) NA   Starting Degree NA   Ending Degree NA

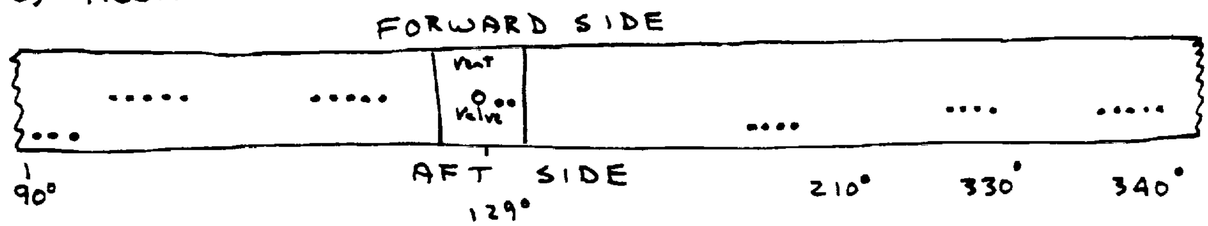
Size: Circumferential Width (in.) NA   Axial Length (in.) NA

Radial Distance (in.) NA

Description:

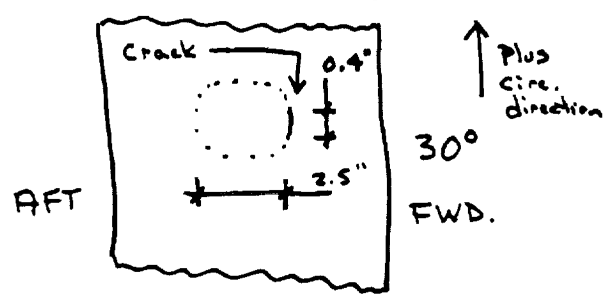
Sketch observation below or attach worksheets and list below. Indicate orientation and dimensions. Show as much detail as necessary to explain the observation.

3) Additional drilled vent holes were noted as follows:



4) No vent hole pattern was drilled at the 30° trunnion location.

5) At the 30° trunnion location a depression was found ~~[illegible]~~ (approximately 2.5 inches in diameter) and a crack (0.4 in. in circumference) was on the forward edge. When the depression was hand-pressed, water flowed out of the crack. See the figure below



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REVISION ___

Table 6
Field Joint External Insulation Condition - Evaluation Checkoff Worksheet

Inspector(s): Mark Perry

Motor No.: STS-30 | Side: ☐ Left ☒ Right | Date: 7 May 1989

Field Joint: ☐ Forward (FWD) ☒ Center (CTR) ☐ Aft (AFT)

Component: JPS

I. External Cork Insulation

A. Voids or Missing Material >0.7 cu.in. (TPSVD)? ___ yes ✓ no

B. Debonds (DEBND)? ___ yes ✓ no

C. Charred Material (HTAFF)? ___ yes ✓ no

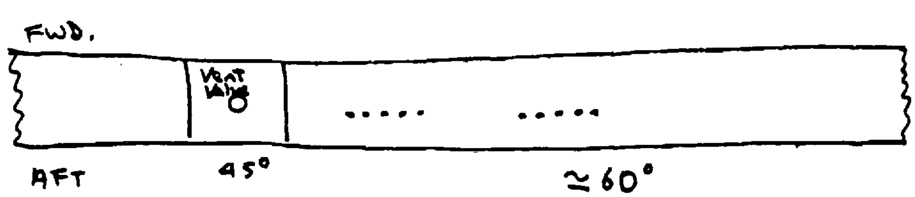
If any of the above conditions exist, note:

Condition (Observation Code)	Axial Location (Station) (In.)	Starting Degree Location (Deg.)	Ending Degree Location (Deg.)	Circumferential Width (In.)	Axial Length (In.)	Radial Depth (In.)

Notes / Comments

1) K5NA repairs, 1.5 in. diameter, on the leading edge where pull tests were performed pre-flight (Repairs at 60°, 150°, 240°, and 330°).

2) Additional drilled vent holes were noted as follows:



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Thiokol CORPORATION
SPACE OPERATIONS

Table 7
Field Joint External Insulation Condition - Evaluation Checkoff Worksheet

Inspector(s): Mark Perry

Motor No.: STS-30 | Side: ☐ Left ☒ Right | Date: 7 May 1989

Field Joint: ☐ Forward (FWD) ☐ Center (CTR) ☒ Aft (AFT)

Component: JPS

I. External Cork Insulation

A. Voids or Missing Material >0.7 cu.in. (TPSVD)? ____ yes ✓ no

B. Debonds (DEBND)? ____ yes ✓ no

C. Charred Material (HTAFF)? ____ yes ✓ no

If any of the above conditions exist, note:

Condition (Observation Code)	Axial Location (Station) (In.)	Starting Degree Location (Deg.)	Ending Degree Location (Deg.)	Circumferential Width (In.)	Axial Length (In.)	Radial Depth (In.)

Notes / Comments

1) K5NA repairs, 1.5 in. diameter, on the leading edge where pull tests were performed pre-flight (Repairs at 60°, 150°, 240°, and 330°).

2) Additional repairs and drilled holes were noted as follows:

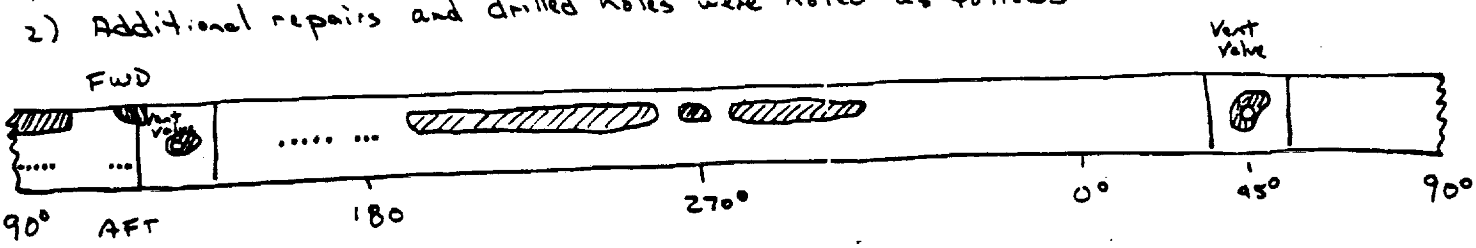

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Table 8 Post-Flight Observation Record (Supplement 3)

FIELD JOINT PROTECTION SYSTEM
LEADING EDGE BONDLINE EVALUATION

DATE: 5-8-89
INSPECTORS: Mark Perry
MOTOR NO.: STS-30 SIDE: X LEFT (A) ___ RIGHT (B)
JOINT: X AFT ___ CENTER ___ FORWARD

NOTE: DOCUMENT ALL VOIDS/UNBONDS GREATER THAN 2 SQUARE INCHES AND WITH AN ASPECT RATIO LESS THAN 10 (LENGTH/WIDTH)

CIRC	MAXIMUM DIMENSIONS			AVERAGE DIMENSIONS			
LOC	CIRC	AXIAL	RADIAL	CIRC	AXIAL	RADIAL	COMMENTS
20°	30.3	2.25	.05	NA	2.25	.05	Dendritic, growing forward, 50% VOID AREA
295°	8.4	1.6	.05	NA	1.3	.05	Single void - without many fingers
268°	13.5	2.3	.05	NA	2.3	.05	Dendritic No Direction 70% VOID AREA
178°	3.3	2.1	.07	NA	2.0	.05	70% Void, Location of Butt Joint
160°	4.3	1.7	.05	NA	1.5	.05	Several interconnected Fingers
140°	2.2	2.0	.05	NA	1.7	.05	Starts @ Sensor & Runs Forward
120°	12.0	2.2	.08	NA	2.0	.05	60% void Area

General Notes:

90 - 20	95% Void Free
0 - 290	90% Void Free - A few voids at 1 in² and less
250 - 200	95% Void Free
200 - 160	90% Void Free
160 - 90	80% Void Free

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Table 9 Post-Flight Observation Record (Supplement 3)
FIELD JOINT PROTECTION SYSTEM
LEADING EDGE BONDLINE EVALUATION

DATE: 5-8-89
INSPECTORS: Mark Perry
MOTOR NO.: STS-30 SIDE: X LEFT (A) ___ RIGHT (B)
JOINT: ___ AFT X CENTER ___ FORWARD

NOTE: DOCUMENT ALL VOIDS/UNBONDS GREATER THAN 2 SQUARE INCHES AND WITH AN ASPECT RATIO LESS THAN 10 (LENGTH/WIDTH)

CIRC	MAXIMUM DIMENSIONS			AVERAGE DIMENSIONS			
LOC	CIRC	AXIAL	RADIAL	CIRC	AXIAL	RADIAL	COMMENTS
260°	25	1.3	0.15	NA	0.6	0.10	Over Sensor, intermittent / interconnected
140	33.5	3.2	0.1	NA	3.0	0.05	40% Cork Bond / 60% Void - Dendritic } Growing Forward
120	32	3.5	0.1	NA	3.0	0.05	40% Cork Bond / 60% Void - Dendritic } Growing Forward

General Notes
90 - 40 (One piece of cork) - 99% Void Free
40 - 5 90% Void Free
5 - 270 A lot of EA934 NA -to- Paint Failure from chiseling - No large voids
240 - 160 85% Void Free, Some Epoxy / Paint Chipping, Thick Bonds & Voids over RTD
160 - 90 40% Void Free,

Thiokol CORPORATION
SPACE OPERATIONS

Table 10
Observation Clarification Form

Motor No. STS-30   Inspector(s) Mark Perry

☐ Left (A) ☒ Right (B)   Date 8 May 1989

Segment: ☒ Forward ☒ Forward Center ☐ Aft Center ☐ Aft ☐ Nozzle

Joint: Forward Field Joint   Case End: NA

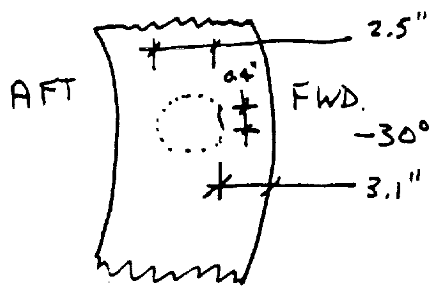
Location: Axial (In.) NA   Starting Degree 30°   Ending Degree 30°

Size: Circumferential Width (In.) NA   Axial Length (In.) NA

Radial Distance (In.) NA

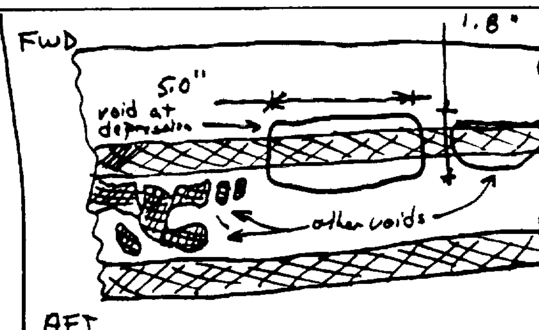
Description:

Sketch observation below or attach worksheets and list below. Indicate orientation and dimensions. Show as much detail as necessary to explain the observation.



FJPS on the motor

- A 2.5" diameter depression in the cork
- A 0.4" Circumferential crack through the cork and paint. The paint covered the ends of the cork crack. The cork crack appeared to run 1.3"



Extruded Cork Off the Motor

- void at depression was 0.3 to 0.4 inch deep (radial)

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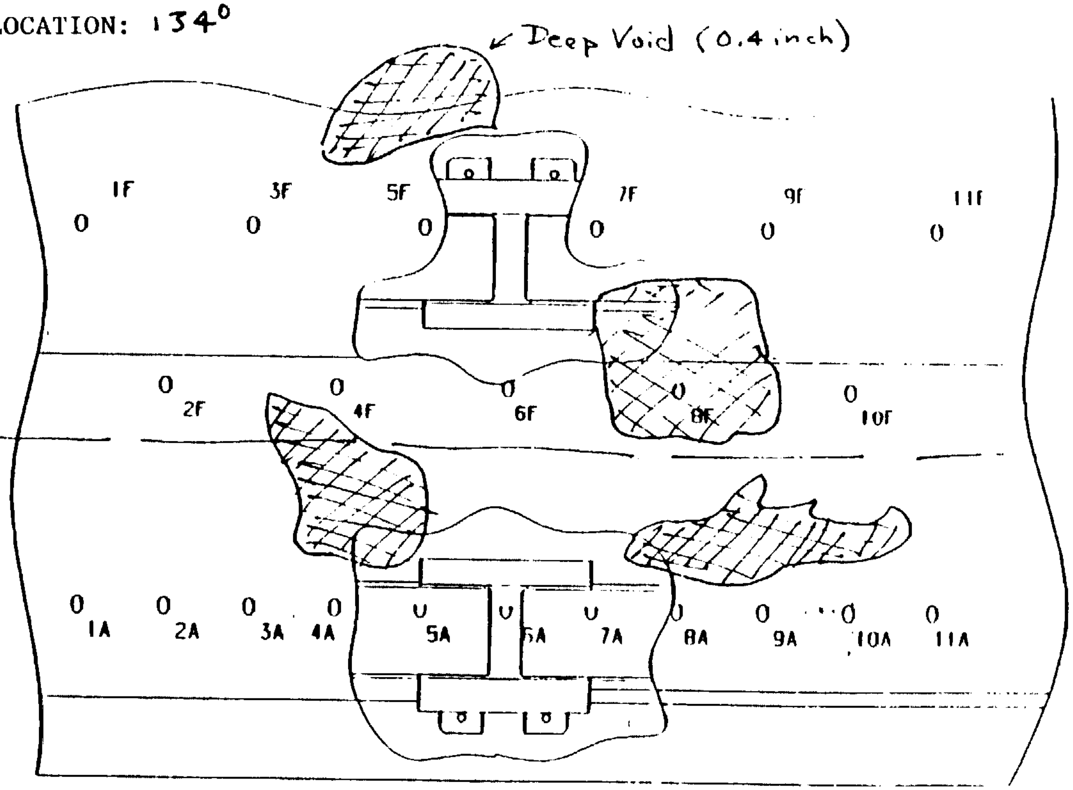
Table 11 Post-Flight Observation Record (Supplement 1)

FIELD JOINT PROTECTION SYSTEM
KEVLAR STRAP BUCKLE VENT HOLE PATTERN ASSESSMENT

DATE: 5-9-89
INSPECTORS: Mark Perry, Elgie Hale
MOTOR NO.: STS-30 SIDE: X LEFT (A) ___ RIGHT (B)
JOINT: X AFT ___ CENTER ___ FORWARD
FORWARD BUCKLE
CIRCUMFERENTIAL LOCATION: 137°
AFT BUCKLE
CIRCUMFERENTIAL LOCATION: 134°



The aft strap should be shifted 6 scale inches to the right to represent the actual orientation.

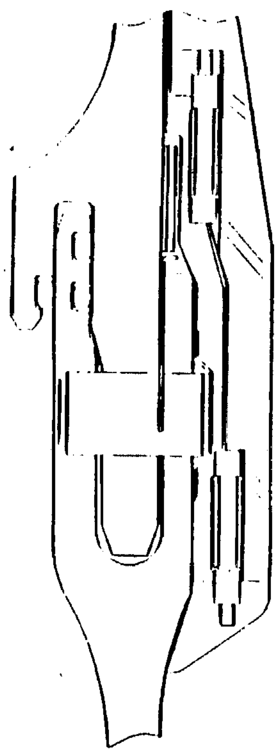


Table 12
Post-Flight Observation Record (Supplement 1)

FIELD JOINT PROTECTION SYSTEM
KEVLAR STRAP BUCKLE VENT HOLE PATTERN ASSESSMENT

DATE: 5-9-89
INSPECTORS: Mark Perry, Elgie Hale
MOTOR NO.: STS-30 SIDE: X LEFT (A) ___ RIGHT (B)
JOINT: X AFT ___ CENTER ___ FORWARD

FORWARD BUCKLE
CIRCUMFERENTIAL LOCATION: 137
DISTANCE BETWEEN CENTERLINES OF BUCKLE AND HOLE PATTERN: 1"
Buckle Centered at hole 5

HOLE NUMBER	DRILLED THROUGH?	VOID AT HOLE?	HIT VOID?	COMMENTS
1F	No	No		
2F	No	No		
3F	No	Yes		
4F	No	Yes		
5F	No	No		
6F	No	No		
7F	No	No		
8F	No	Yes		
9F	No	No		
10F	No	No		
11F	No	No		

AFT BUCKLE
CIRCUMFERENTIAL LOCATION: 134
DISTANCE BETWEEN CENTERLINES OF BUCKLE AND HOLE PATTERN: 1"
Buckle Centered at Hole #7

HOLE NUMBER	DRILLED THROUGH?	VOID AT HOLE?	HIT VOID?	COMMENTS
1A	No	No		
2A	No	No		
3A	No	No		
4A	No	No		
5A	No	Yes		
6A	No	Yes		
7A	No	No		
8A	No	No		
9A	No	No		
10A	No	No		
11A	No	No		

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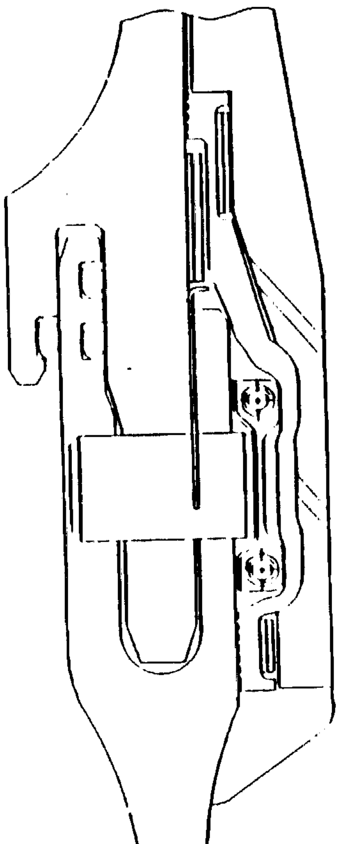
Table 13 Post-Flight Observation Record (Supplement 2)
FIELD JOINT PROTECTION SYSTEM
HAT BAND TRUNNION VENT HOLE PATTERN ASSESSMENT

DATE: 5-9-89
INSPECTORS: Mark Perry, Elgie Hale
MOTOR NO.: STS-30 SIDE: X LEFT (A) __RIGHT (B)
JOINT: X AFT __CENTER __FORWARD
CIRCUMFERENTIAL LOCATION: X 30 __150 __270



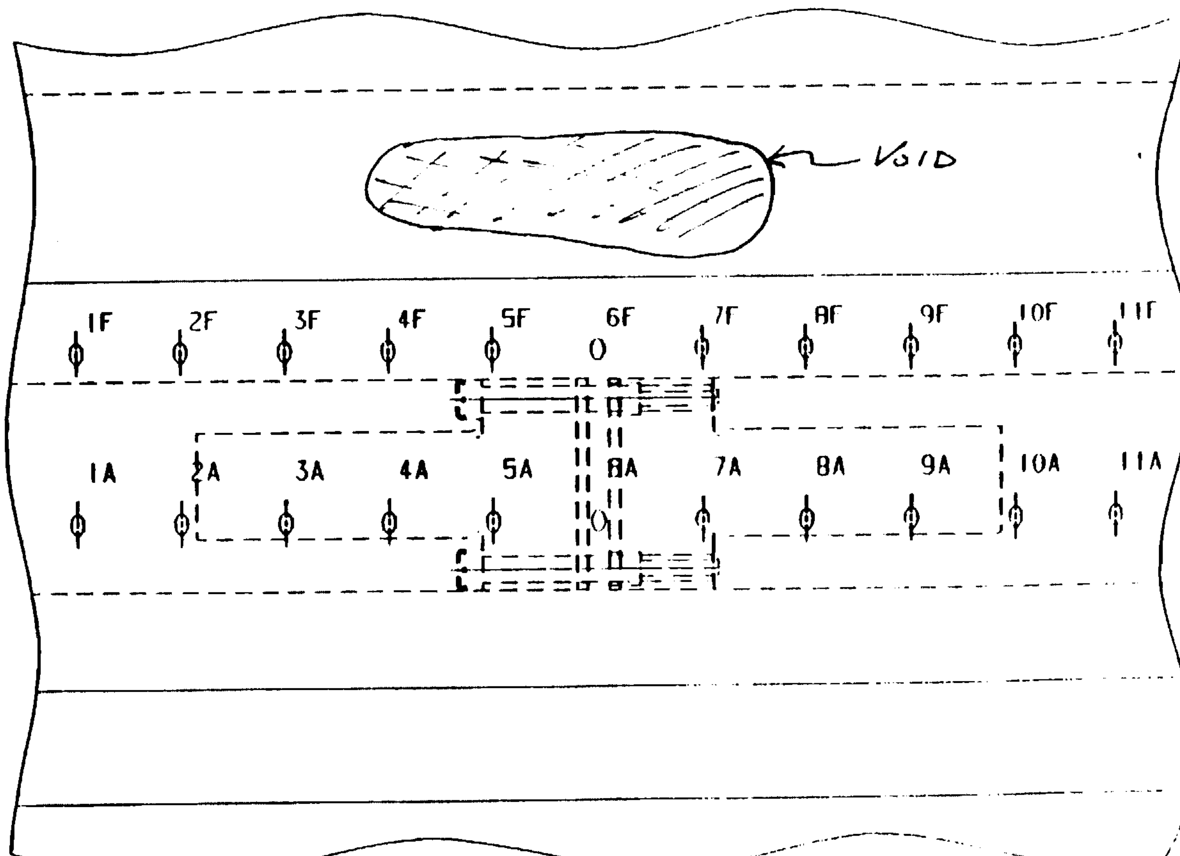


Table 14
Post-Flight Observation Record (Supplement 2)

FIELD JOINT PROTECTION SYSTEM
HAT BAND TRUNNION VENT HOLE PATTERN ASSESSMENT

DATE: 5-9-89
INSPECTORS: Mark Perry , Elgie Hale
MOTOR NO.: STS-30 SIDE: X LEFT (A) ___RIGHT (B)
JOINT: X AFT ___CENTER ___FORWARD
CIRCUMFERENTIAL LOCATION: ___30 X 150 ___270

DISTANCE BETWEEN CENTERLINES OF TRUNNION AND HOLE PATTERN: N4

HOLE NUMBER	DRILLED THROUGH?	VOID AT HOLE?	HIT VOID?	COMMENTS
1F				
2F				
3F				
4F				
5F				
6F				
7F				
8F				
9F				
10F				
11F				
1A				
2A				
3A				
4A				
5A				
6A				
7A				
8A				
9A				
10A				
11A				

No hole patterns drilled
Minimum Cork Thickness : 0.25"

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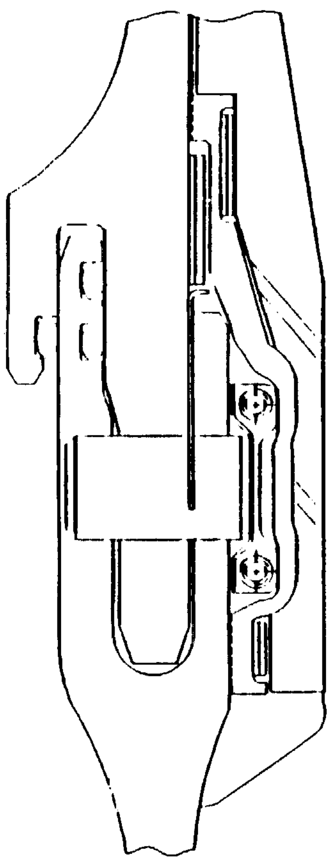
Table 15 Post-FLight Observation Record (Supplement 2)
FIELD JOINT PROTECTION SYSTEM
HAT BAND TRUNNION VENT HOLE PATTERN ASSESSMENT

DATE: 5-9-89
INSPECTORS: Mark Perry, Elgie Hale
MOTOR NO.: STS-30 SIDE: X LEFT (A) __ RIGHT (B)
JOINT: X AFT __ CENTER __ FORWARD
CIRCUMFERENTIAL LOCATION: __ 30 __ 150 X 270



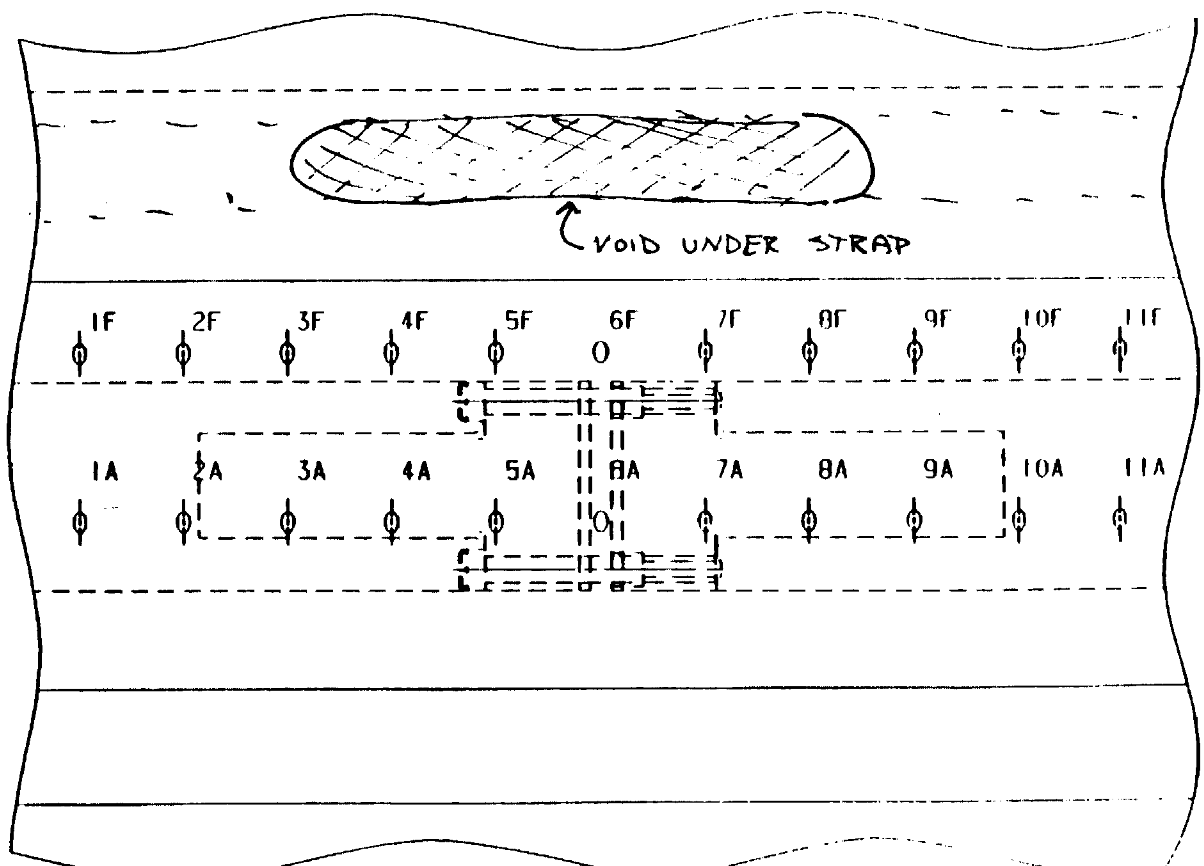


Table 16
Post-Flight Observation Record (Supplement 2)

FIELD JOINT PROTECTION SYSTEM
HAT BAND TRUNNION VENT HOLE PATTERN ASSESSMENT

DATE: 5-9-89
INSPECTORS: Mark Perry, Elgie Hale
MOTOR NO.: STS-30 SIDE: X LEFT (A) ___ RIGHT (B)
JOINT: X AFT ___ CENTER ___ FORWARD
CIRCUMFERENTIAL LOCATION: ___ 30 ___ 150 X 270

DISTANCE BETWEEN CENTERLINES OF TRUNNION AND HOLE PATTERN: 3"
Center of the trunnion lies below hole # 9

HOLE NUMBER	DRILLED THROUGH?	VOID AT HOLE?	HIT VOID?	COMMENTS
1F	No	No		
2F	No	No		
3F	No	No		
4F	No	No		
5F	No	No		
6F	No	No		
7F	No	No		
8F	No	No		
9F	No	No		
10F	No	No		
11F	No	No		
1A	No	No		
2A	No	No		
3A	No	No		
4A	No	No		
5A	No	No		
6A	No	No		
7A	No	No		
8A	No	No		
9A	No	No		
10A	No	No		
11A	No	No		

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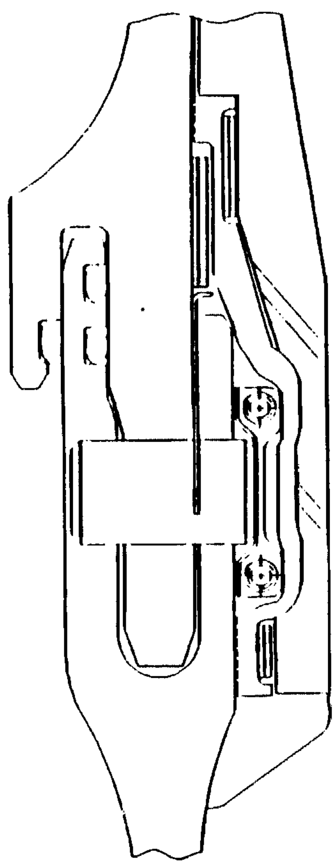
Table 17 Post-Flight Observation Record (Supplement 2)

FIELD JOINT PROTECTION SYSTEM

HAT BAND TRUNNION VENT HOLE PATTERN ASSESSMENT

DATE: 5-9-89
INSPECTORS: Mark Perry, Elgie Hale
MOTOR NO.: STS-30 SIDE: X LEFT (A) ___ RIGHT (B)
JOINT: X AFT ___ CENTER ___ FORWARD
CIRCUMFERENTIAL LOCATION: ___ 30 X 150 ___ 270

No Hole Patterns Drilled



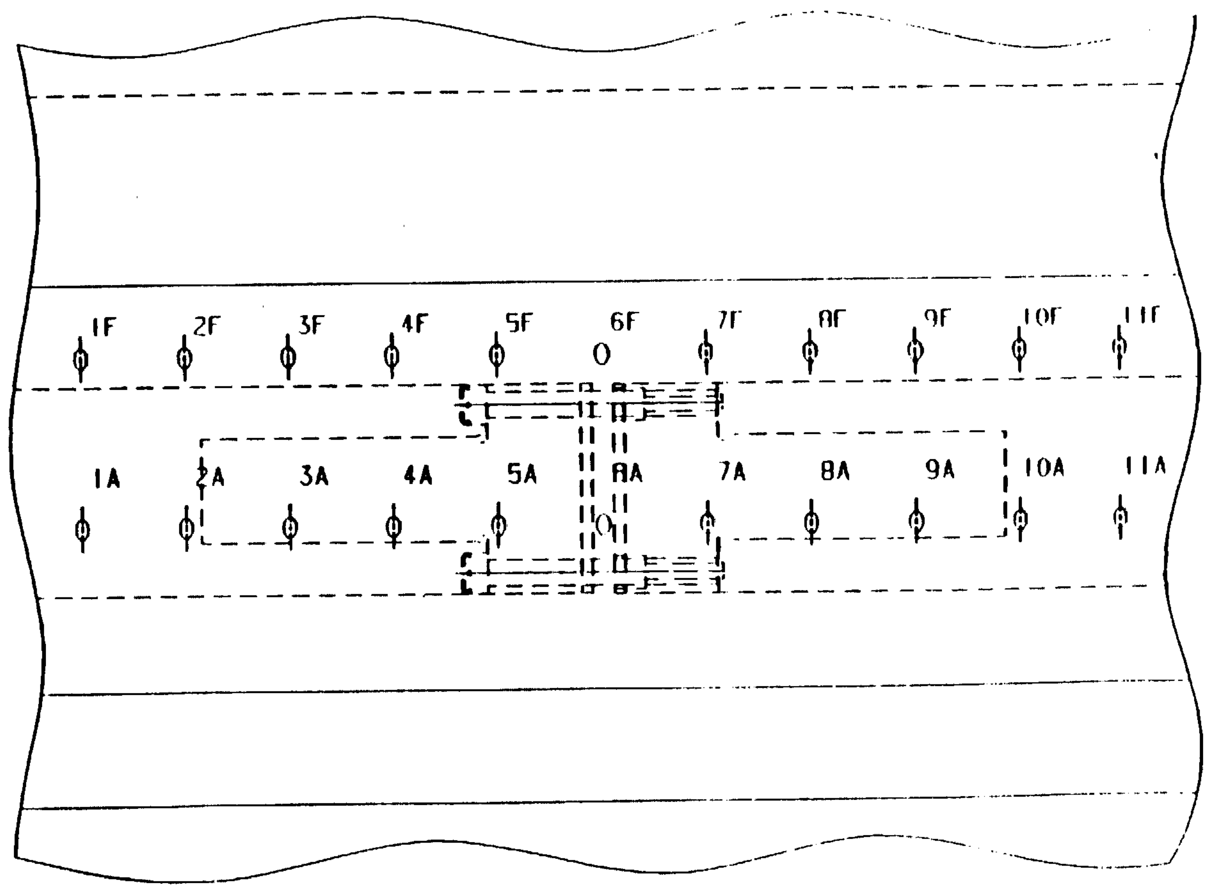


Table 18
Post-Flight Observation Record (Supplement 2)

FIELD JOINT PROTECTION SYSTEM
HAT BAND TRUNNION VENT HOLE PATTERN ASSESSMENT

DATE: 5-9-89
INSPECTORS: Mark Perry, Elgie Hale
MOTOR NO.: STS-30 SIDE: X LEFT (A) ___ RIGHT (B)
JOINT: X AFT ___ CENTER ___ FORWARD
CIRCUMFERENTIAL LOCATION: X 30 ___ 150 ___ 270

DISTANCE BETWEEN CENTERLINES OF TRUNNION AND HOLE PATTERN: 0.0 inch

HOLE NUMBER	DRILLED THROUGH?	VOID AT HOLE?	HIT VOID?	COMMENTS
1F	No	No		
2F	No	No		
3F	No	No		
4F	No	No		
5F	No	No		
6F	No	Yes		
7F	No	Yes		
8F	No	No		
9F	No	No		
10F	No	No		
11F	No	No		
1A	No	No		
2A	No	No		
3A	No	No		
4A	No	No		
5A	No	No		
6A	No	No		
7A	No	No		
8A	No	No		
9A	No	No		
10A	No	No		
11A	No	No		

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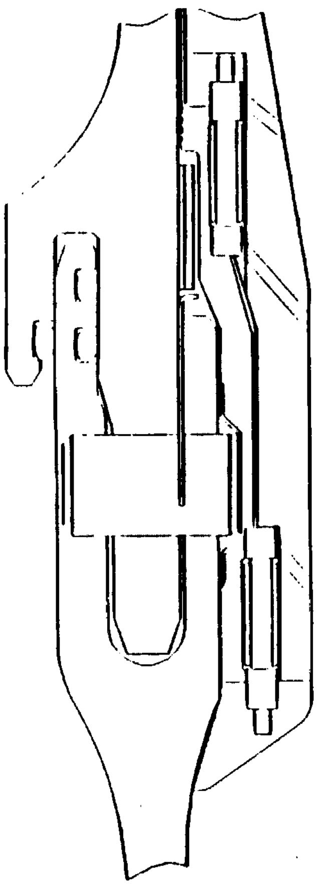
Table 19 Post-Flight Observation Record (Supplement 1)

FIELD JOINT PROTECTION SYSTEM
KEVLAR STRAP BUCKLE VENT HOLE PATTERN ASSESSMENT

DATE: 5-9-89
INSPECTORS: Mark Perry
MOTOR NO.: STS-30 SIDE: X LEFT (A) ___ RIGHT (B)
JOINT: ___ AFT X CENTER ___ FORWARD
FORWARD BUCKLE
CIRCUMFERENTIAL LOCATION: 134°
AFT BUCKLE
CIRCUMFERENTIAL LOCATION: 133°



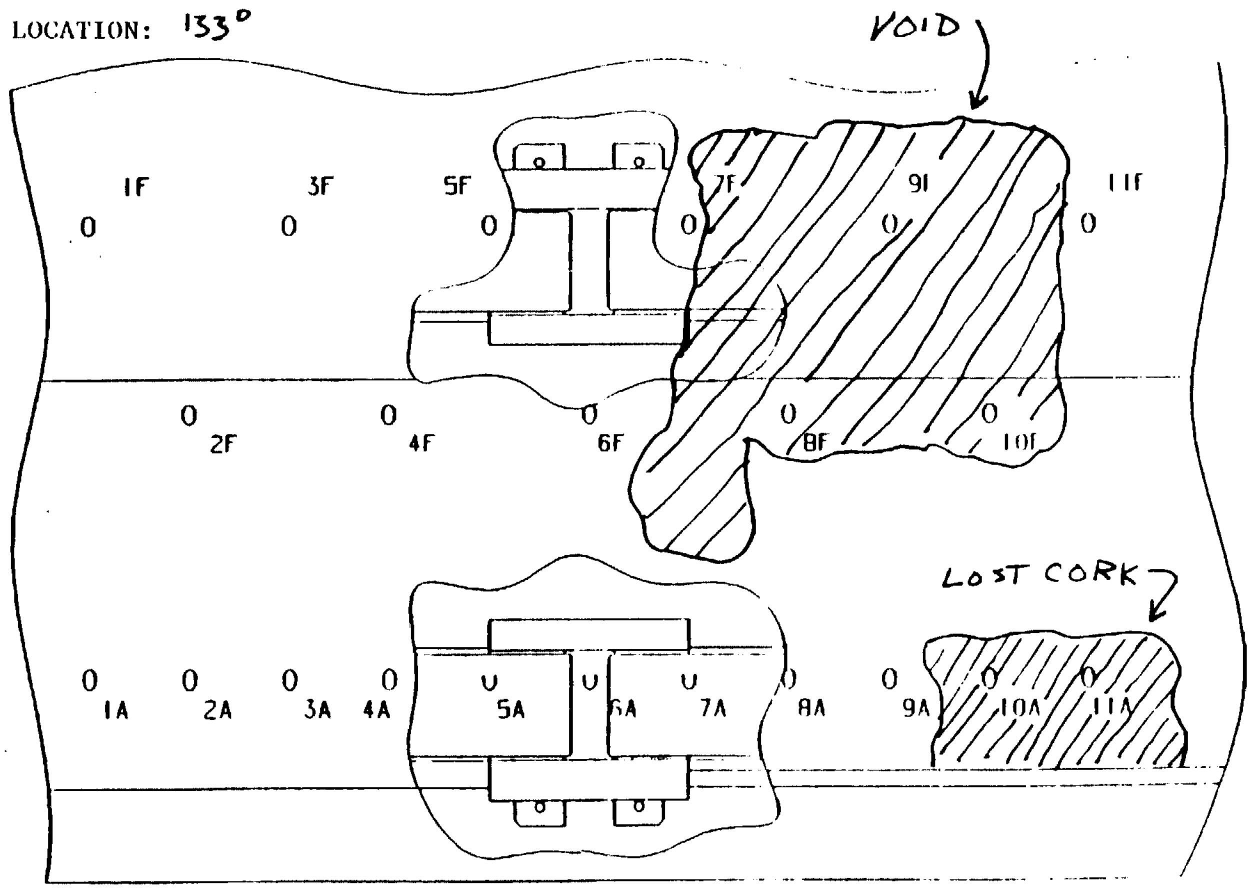


Table 20
Post-Flight Observation Record (Supplement 1)

FIELD JOINT PROTECTION SYSTEM
KEVLAR STRAP BUCKLE VENT HOLE PATTERN ASSESSMENT

DATE: 5-9-89
INSPECTORS: Mark Perry, Elgie Hale
MOTOR NO.: STS-30 SIDE: X LEFT (A) ___ RIGHT (B)
JOINT: ___ AFT X CENTER ___ FORWARD

FORWARD BUCKLE
CIRCUMFERENTIAL LOCATION: 134°
DISTANCE BETWEEN CENTERLINES OF BUCKLE AND HOLE PATTERN: 0.0"

HOLE NUMBER	DRILLED THROUGH?	VOID AT HOLE?	HIT VOID?	COMMENTS
1F	No	No		
2F	No	No		
3F	No	No		
4F	No	No		
5F	No	No		
6F	No	No		
7F	No	No		
8F	No	Yes	No	Same Void
9F	No	Yes	No	Same Void
10F	No	Yes	No	Same Void
11F	No	No		

AFT BUCKLE
CIRCUMFERENTIAL LOCATION: 133°
DISTANCE BETWEEN CENTERLINES OF BUCKLE AND HOLE PATTERN: 0.75"
Centered near hole #7

HOLE NUMBER	DRILLED THROUGH?	VOID AT HOLE?	HIT VOID?	COMMENTS
1A	No	No		
2A	No	No		
3A	No	No		
4A	No	No		
5A	No	No		
6A	No	No		
7A	No	No		
8A	No	No		
9A	No	No		
10A	Lost Cork Fragment — No voids			
11A	Lost Cork Fragment — No voids			

Table 21 Post-Flight Observation Record (Supplement 2)
FIELD JOINT PROTECTION SYSTEM
HAT BAND TRUNNION VENT HOLE PATTERN ASSESSMENT

DATE: 5-9-89
INSPECTORS: Mark Perry
MOTOR NO.: STS-30 SIDE: X LEFT (A) ___ RIGHT (B)
JOINT: ___ AFT X CENTER ___ FORWARD
CIRCUMFERENTIAL LOCATION: X 30 ___ 150 ___ 270

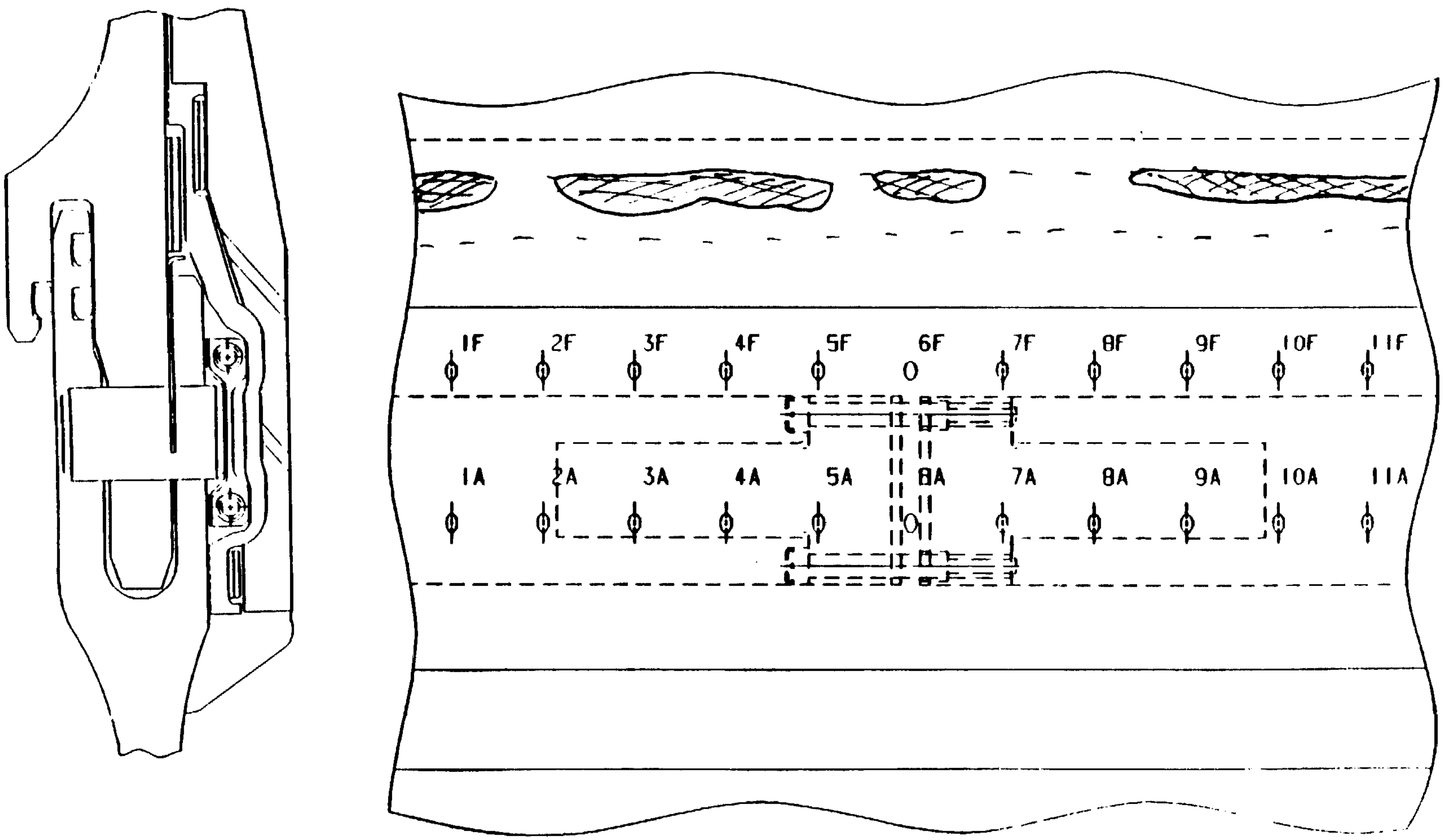


Table 22 Post-Flight Observation Record (Supplement 2)
FIELD JOINT PROTECTION SYSTEM
HAT BAND TRUNNION VENT HOLE PATTERN ASSESSMENT

DATE: 5-9-89
INSPECTORS: Mark Perry
MOTOR NO.: STS-30 SIDE: X LEFT (A) ___ RIGHT (B)
JOINT: ___ AFT X CENTER ___ FORWARD
CIRCUMFERENTIAL LOCATION: ___ 30 X 150 ___ 270

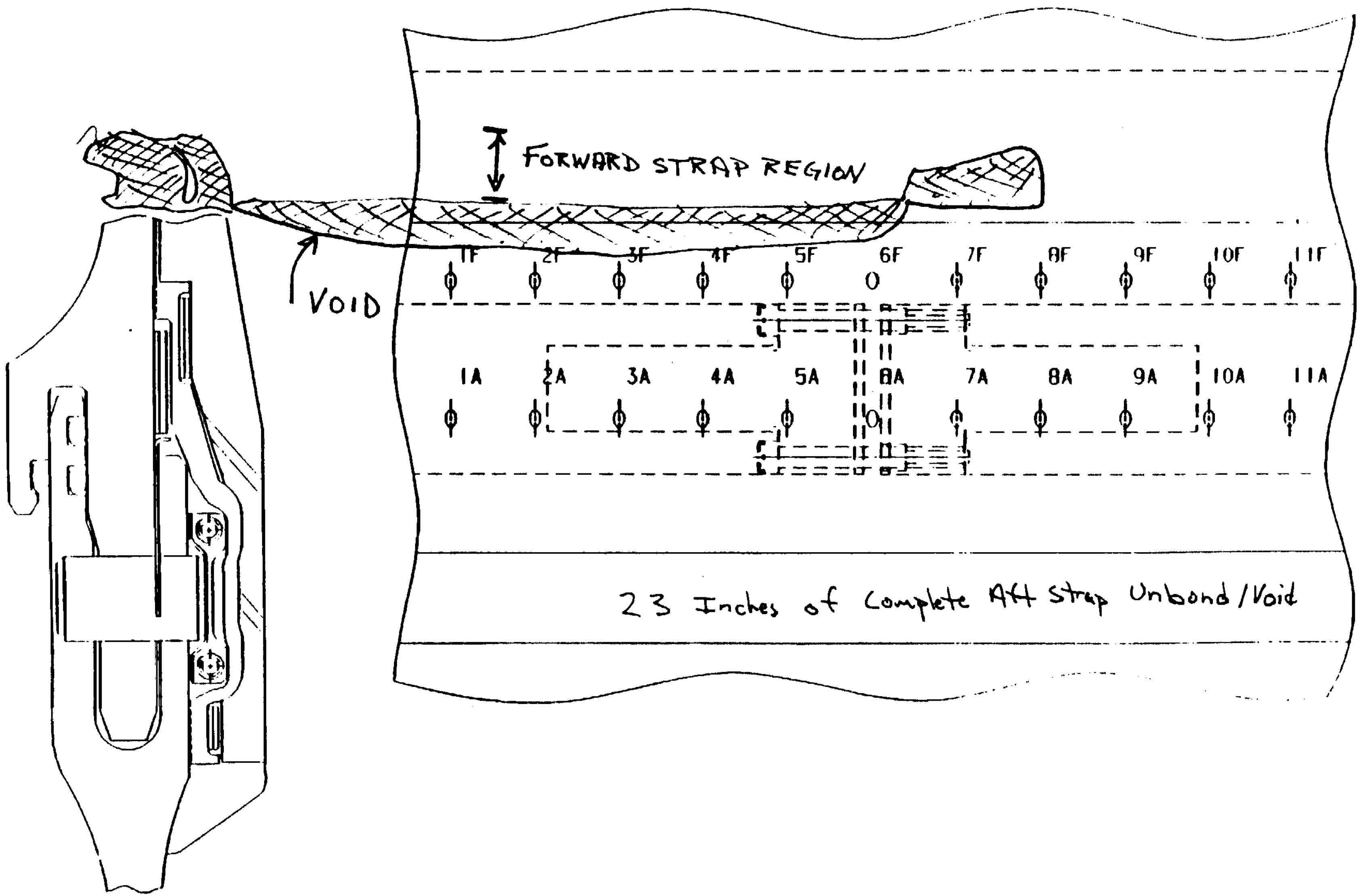


Table 23
Post-Flight Observation Record (Supplement 2)

FIELD JOINT PROTECTION SYSTEM
HAT BAND TRUNNION VENT HOLE PATTERN ASSESSMENT

DATE: 5-9-89
INSPECTORS: Mark Perry, Ebie Hale
MOTOR NO.: STS-30 SIDE: X LEFT (A) ___ RIGHT (B)
JOINT: ___ AFT X CENTER ___ FORWARD
CIRCUMFERENTIAL LOCATION: ___ 30 X 150 ___ 270

DISTANCE BETWEEN CENTERLINES OF TRUNNION AND HOLE PATTERN:

HOLE NUMBER	DRILLED THROUGH?	VOID AT HOLE?	HIT VOID?	COMMENTS NO HOLES DRILLED
1F				
2F				
3F				
4F				
5F				
6F				
7F				
8F				
9F				
10F				
11F				
1A				
2A				
3A				
4A				
5A				
6A				
7A				
8A				
9A				
10A				
11A				

MIN. CORK THICKNESS IS .25

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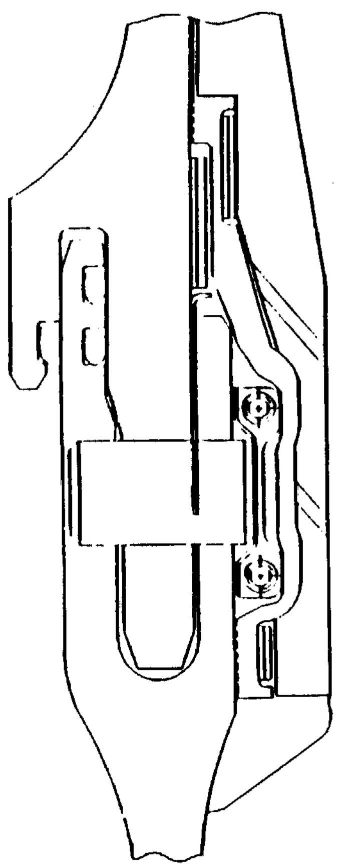
Table 24 Post-Flight Observation Record (Supplement 2)

FIELD JOINT PROTECTION SYSTEM

HAT BAND TRUNNION VENT HOLE PATTERN ASSESSMENT

DATE: 5-9-89
INSPECTORS: Mark Perry
MOTOR NO.: STS-30   SIDE: X LEFT (A)   ___ RIGHT (B)
JOINT: ___ AFT   X CENTER   ___ FORWARD
CIRCUMFERENTIAL LOCATION: ___ 30   ___ 150   X 270



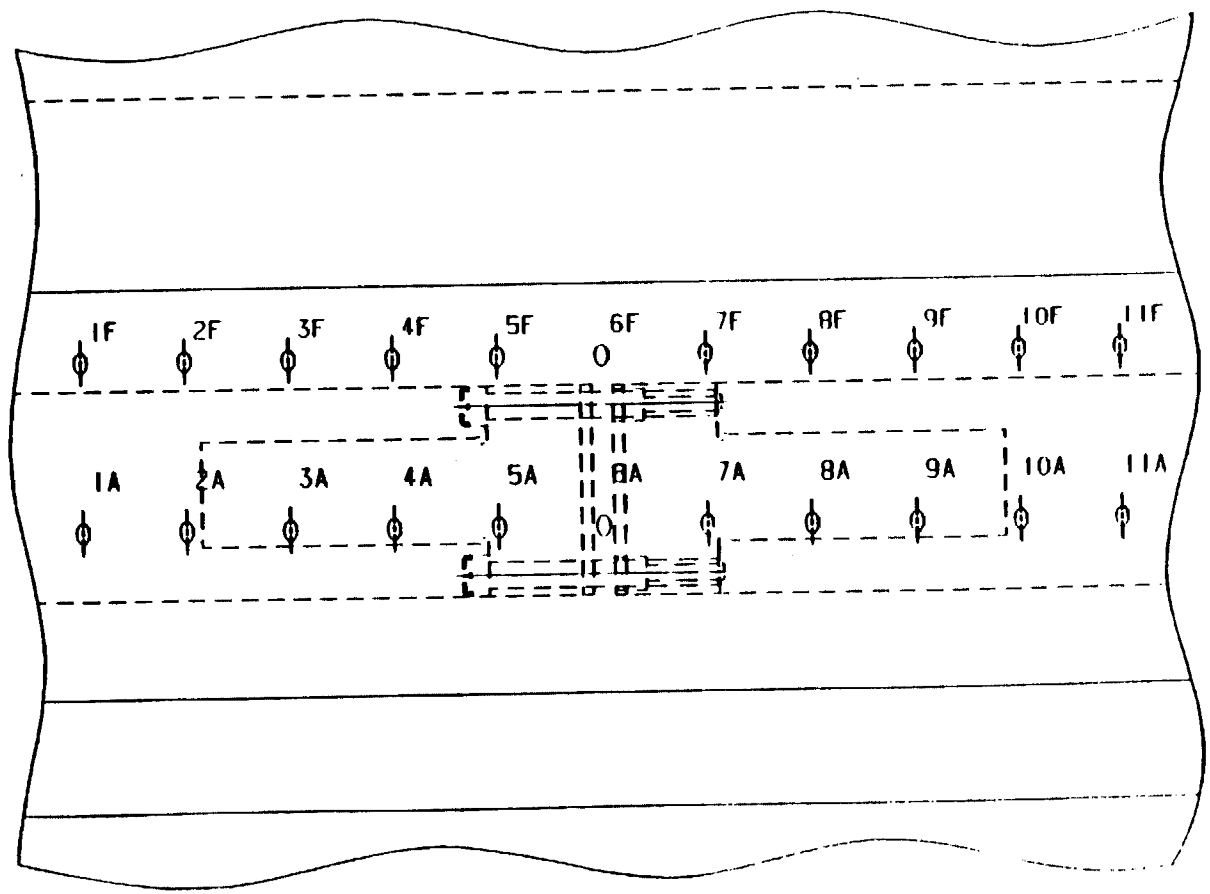


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Table 25
Post-Flight Observation Record (Supplement 2)

FIELD JOINT PROTECTION SYSTEM
HAT BAND TRUNNION VENT HOLE PATTERN ASSESSMENT

DATE: 5-9-89
INSPECTORS: Mark Perry, Elgie Hale
MOTOR NO.: STS-30 SIDE: X LEFT (A) ___ RIGHT (B)
JOINT: ___ AFT X CENTER ___ FORWARD
CIRCUMFERENTIAL LOCATION: ___ 30 ___ 150 X 270
Trunnion centered at hole #7 location
DISTANCE BETWEEN CENTERLINES OF TRUNNION AND HOLE PATTERN: 1"

HOLE NUMBER	DRILLED THROUGH?	VOID AT HOLE?	HIT VOID?	COMMENTS
1F	NO	NO		MIN. CORK THICKNESS 0.29"
2F	NO	NO		
3F	NO	NO		
4F	NO	NO		
5F	Yes	NO		
6F	Yes	NO		
7F	Yes	NO		
8F	Yes	NO		
9F	NO	NO		
10F	NO	NO		
11F	NO	NO		
1A	NO	NO		
2A	NO	NO		
3A	NO	NO		
4A	NO	NO		
5A	NO	NO		
6A	NO	NO		
7A	NO	NO		
8A	NO	NO		
9A	NO	NO		
10A	NO	NO		
11A	NO	NO		

Table 26
Field Joint Heater Cable External Insulation Condition - Eval Checkoff Worksheet

Inspector(s): Mark Perry / Elzie Hale

Motor No.: STS-30 | Side: ☐ Left (A) ☒ Right (B) | Date: 7 May 1989

Component: TPS

I. External Cork Insulation
   A. Voids or Missing Material >0.7 cu.in. (TPSVD)? ____ yes ✓ no
   B. Debonds (DEBND)? ____ yes ✓ no
   C. Charred (HTAFF)? ____ yes ✓ no

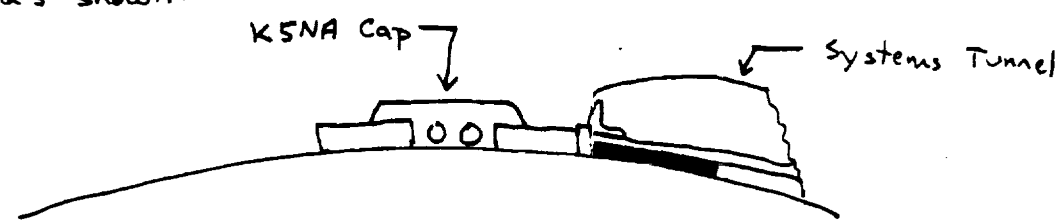
II. Cables Debonded (DEBND) if visible? ____ yes ✓ no

If any of the above conditions exist, note:

Segment (FWD, FCS, ACS or AFT)	Condition (Observation Code)	Axial Location (Station) (In.)	Starting Degree Location (Deg.)	Ending Degree Location (Deg.)	Circumferential Width (In.)	Axial Length (In.)

Notes / Comments

The forward, forward/center, and aft/center configurations were as shown:



REVISION ____

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Table 27
Field Joint Heater Cable External Insulation Condition - Eval Checkoff Worksheet

Inspector(s): Mark Perry / Elgie Hale

Motor No.: STS-30 | Side: ☒ Left (A) ☐ Right (B) | Date: 7 May 1989

Component: TPS

I. External Cork Insulation
A. Voids or Missing Material >0.7 cu.in. (TPSVD)? ___ yes ✓ no
B. Debonds (DEBND)? ___ yes ✓ no
C. Charred (HTAFF)? ___ yes ✓ no
II. Cables Debonded (DEBND) if visible? ___ yes ✓ no

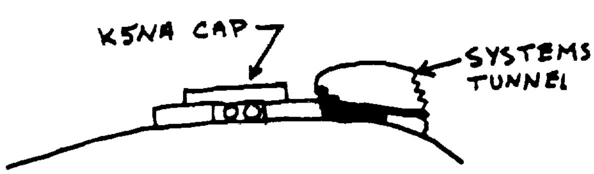
If any of the above conditions exist, note:

Segment (FWD, FCS, ACS or AFT)	Condition (Observation Code)	Axial Location (Station) (In.)	Starting Degree Location (Deg.)	Ending Degree Location (Deg.)	Circumferential Width (In.)	Axial Length (In.)

Notes / Comments

The configurations were as follows:

Aft/Center Segment



Forward and Forward/Center Segments

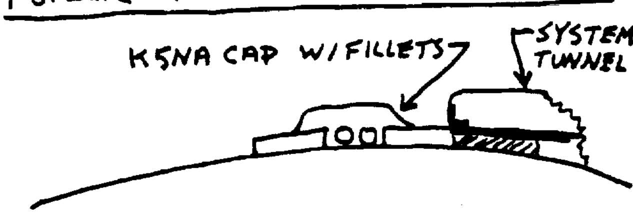


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Table 28
Igniter Heater Installation Condition - Evaluation Checkoff Worksheet

Inspector(s): Elgie Hale		
Motor No.:	Side: ☒ Left (A) ☒ Right (B)	Date: 5/7/89
Joint: Igniter (IGN)	Case End: Igniter Adapter (FWD)	Component: JPS

I. Igniter Heater
- A. Unsecure(LOOSE)? ____ yes ✓ no
- B. Improper position (DISCP)? ____ yes ✓ no

II. Cork Insulation
- A. Unsecure(LOOSE)? ____ yes ✓ no
- B. Improper position (DISCP)? ____ yes ✓ no

III. T-Bolt Latch Band Clamp
- A. Unsecure(LOOSE)? ____ yes ✓ no
- B. Improper position (DISCP)? ____ yes ✓ no

IV. Igniter Heater Power Cables
- A. Unsecure(LOOSE)? ____ yes ✓ no
- B. Improper position (DISCP)? ____ yes ✓ no

If any of the above conditions exist, note:

Affected Part (I, II, III or IV)	Condition (Observation Code)	Starting Degree Location (Deg.)	Ending Degree Location (Deg.)	Circumferential Width (In.)	Axial Length (In.)

Notes / Comments

Table 29
Igniter Heater Component - Evaluation Checkoff Worksheet

Inspector(s): Elgie Hale		
Motor No.:	Side: [X] Left [X] Right	Date: 5/7/89
Joint: Igniter (IGN)	Case End: Igniter Adapter (FWD)	Component: JPS

I.	T-Bolt Latch Band Clamp Assembly Intact (BAND)?	✓ yes	___ no
II.	Igniter Heater		
	A. Delaminations (DLHTR)?	___ yes	✓ no
	B. Discolorations (DSCLR)?	___ yes	✓ no
	C. Charred (HTAFF)?	___ yes	✓ no
	D. Warped (HTAFF)?	___ yes	✓ no
III.	Heater Power Cables		
	A. Not Intact (LOOSE)?	___ yes	✓ no
	B. Charred (HTAFF)?	___ yes	✓ no

If any of the above conditions exist, note:

Affected Part (I, II or III)	Condition (Observation Code)	Axial Location (Station) (In.)	Starting Degree Location (Deg.)	Ending Degree Location (Deg.)	Circumferential Width (In.)	Axial Length (In.)

Notes / Comments